THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

1957

THE INSTITUTION OF

PRODUCTION ENGINEERS JOURNAL

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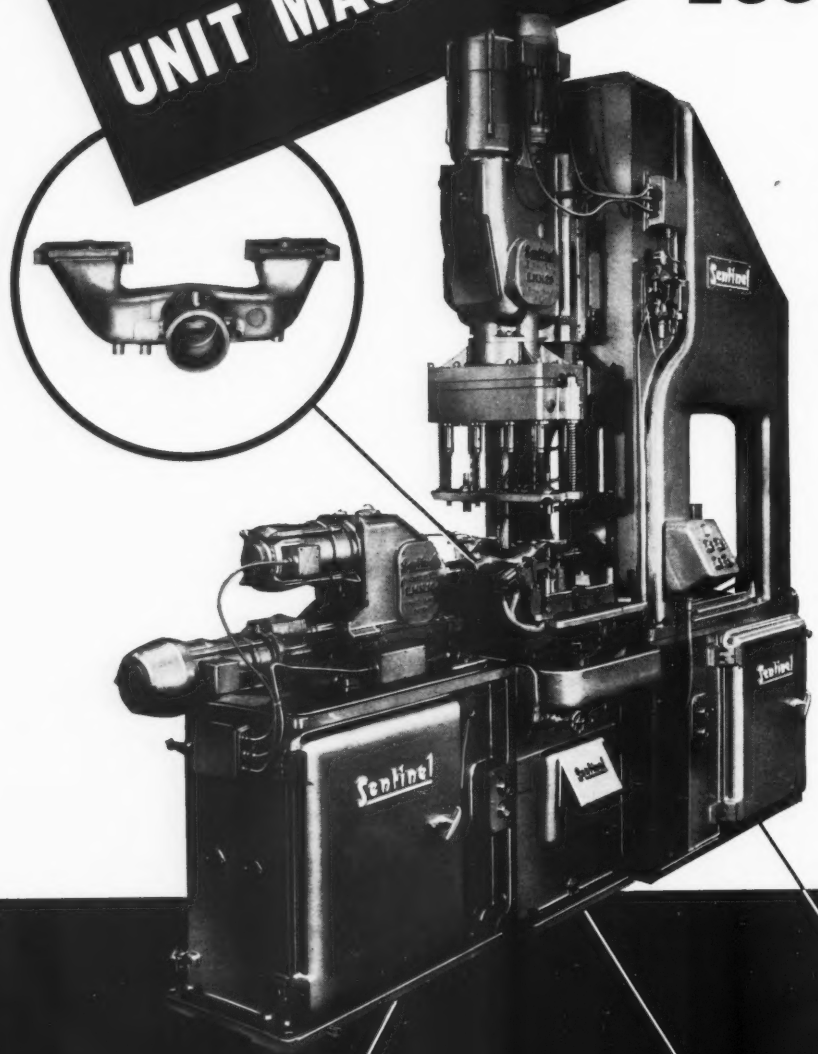

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Built for—Drilling, Boring, Facing and Chamfering. 8 different types of Manifolds (see *inset*). Two manifolds are loaded, pneumatically located and clamped.
Press a button to start—and in less than 30 seconds the machining cycle is completed!

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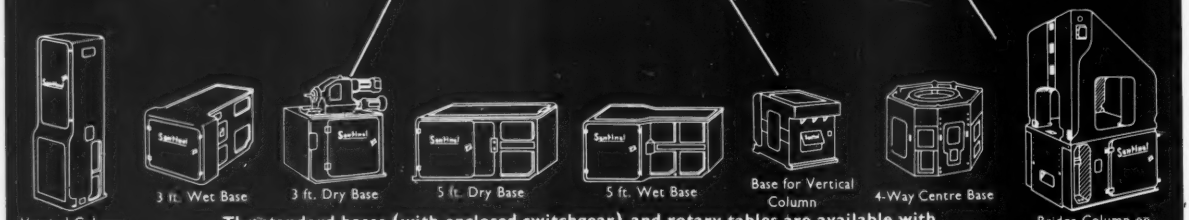
3 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
3 way Centre Base.
4 ft. Dry Base, and an EMH 10 with Boring, Facing and Chamfering Tools.
Bridge Column, and an EMH 20 with a 12 multi-spindle head.


Vertical Column 7-8-9 ft.
3 ft. Wet Base
3 ft. Dry Base
5 ft. Dry Base
5 ft. Wet Base
Base for Vertical Column
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The standard bases (with enclosed switchgear) and rotary tables are available with machined mating faces for assembly into any combination of units.

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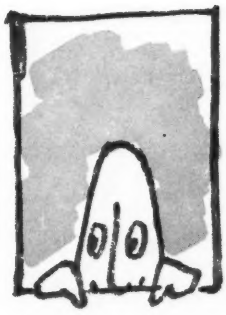

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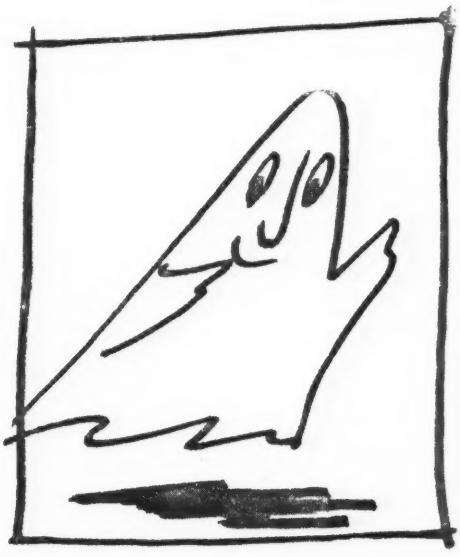

. . . meet Max Am

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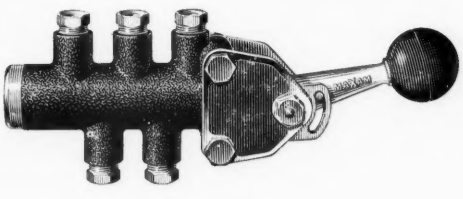
MAXAM



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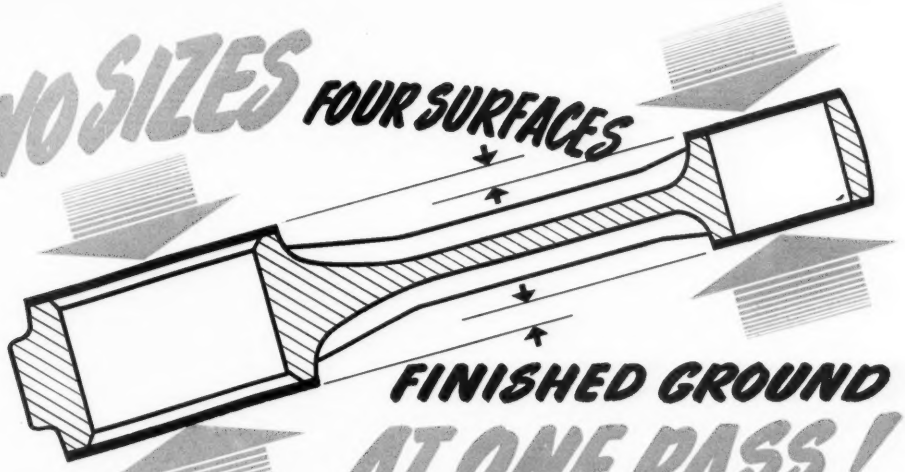

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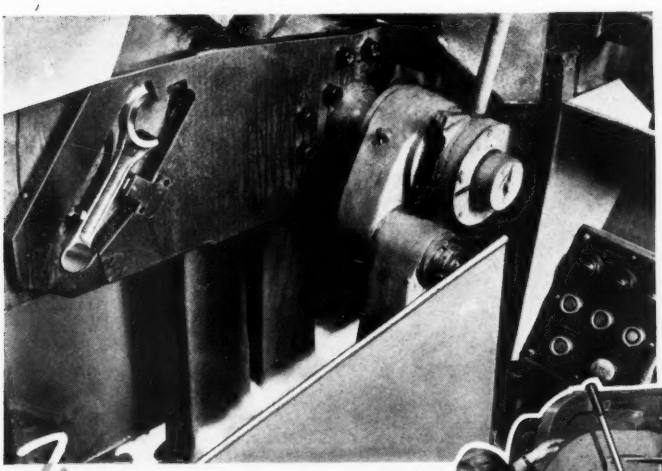

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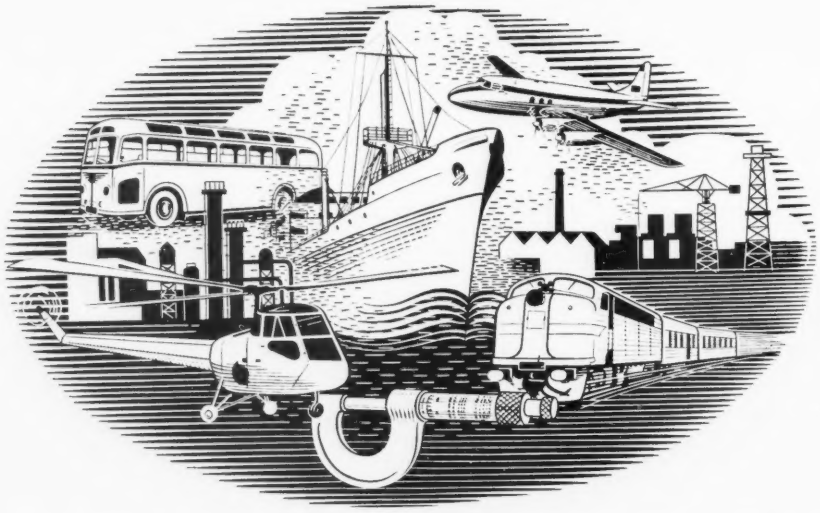

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The idea that a strong screw had to be good and big would now be regarded as a joke, but in the Before-Unbrako era it was true. Unbrako showed how it was possible to miniaturise—to use fewer and smaller screws to do the same job.

Unbrako brought a new way of thinking to screwmaking, the scientific way. Revolutionary designs and superb craftsmanship allied to the finest alloy steels and heat treatment made it possible to produce a ***better*** *screw—a higher tensile screw — a screw with infinitely greater fatigue resistance — and a better made screw altogether.*

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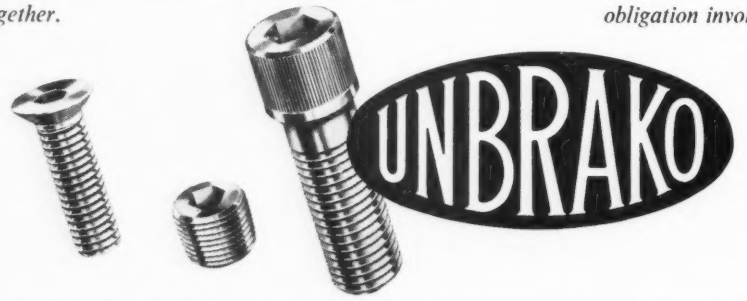

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How? If you had to speed the smoothing of flame-cut edges, what would you design? CARBORUNDUM research developed the CARBOFLEX (trade mark) depressed-centre wheel, which "gives" to, and absorbs, the jolting shocks that shorten the life of rigid, slower implements for smoothing. How to abolish the time loss, in resetting, when the tungsten-carbide teeth of a milling cutter are sharpened? Research by CARBORUNDUM perfected resin-bonded diamond wheels which show negligible wear, and need setting once only. Faster optical lens production, granite cutting, road making? CARBORUNDUM research has helped to solve a thousand different problems. If you want to maintain quality, and yet speed production, ask the Indian head "How?". The odds are he will be able to tell you how. Specialist advice is part of the CARBORUNDUM service to industry.

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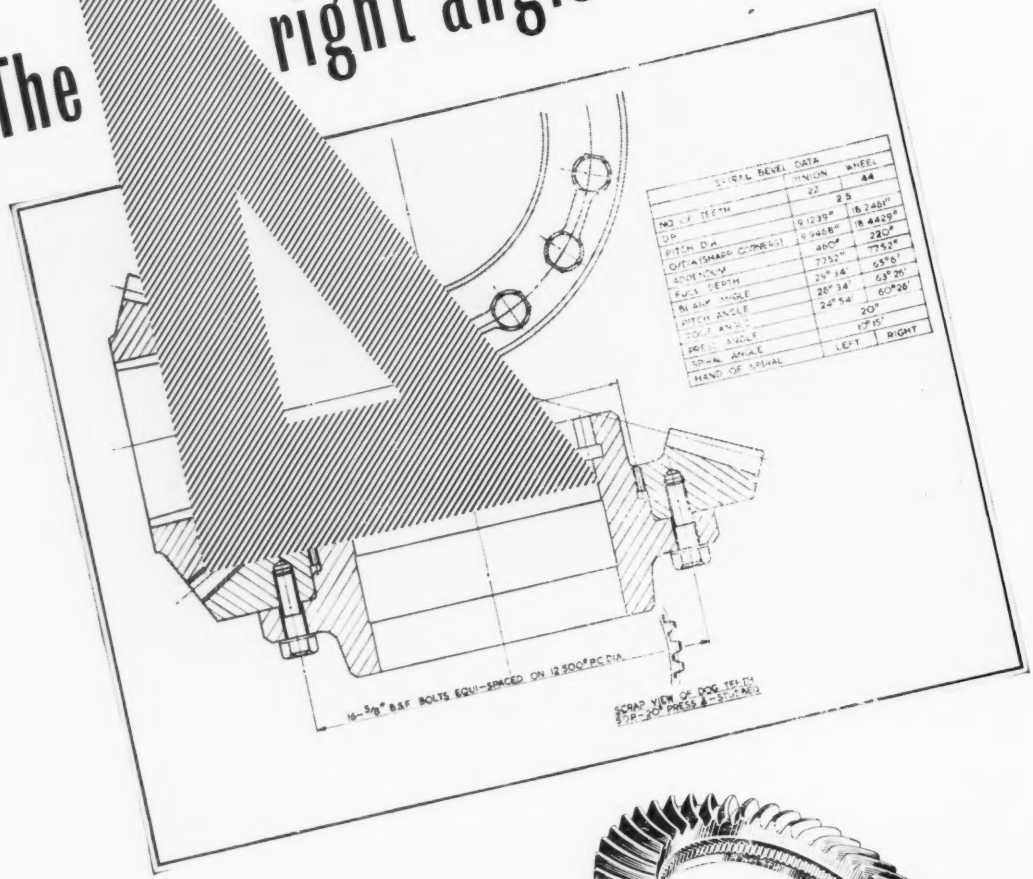
The right angle on gears



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a really low cost top quality motor

the NEW

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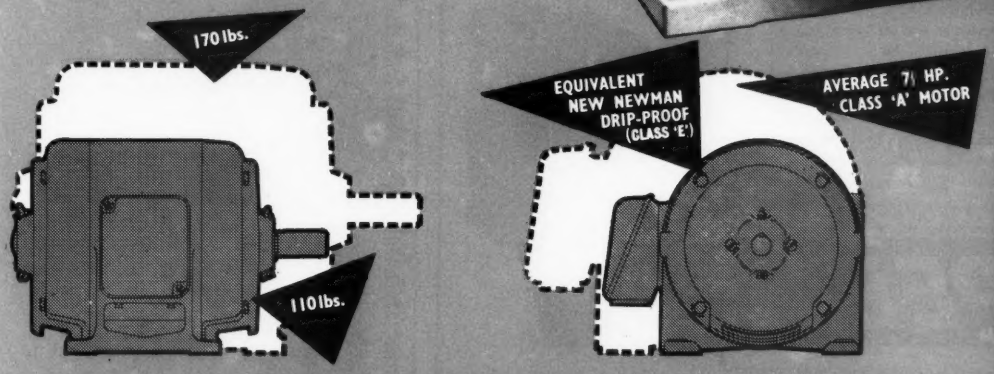

Compare these drawings: the black outline shows approximately the space occupied by an average 7½ h.p. class 'A' insulated drip-proof motor compared with the equivalent new Newman Drip Proof —a considerable saving in space. Now take a look at the weight figures—a saving of 60 lbs.

What are the vital characteristics a designer looks for when specifying a motor—efficiency? reliability? compactness? The new Newman drip proof has them all **and** at a **really** low price.

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H.P.	Syn. Speed r.p.	
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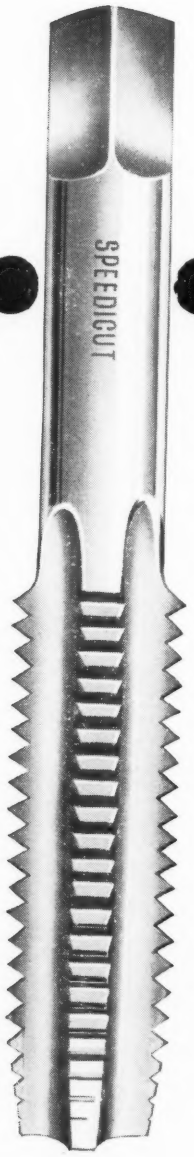
¾	1000	7
1	1500 750	10
1½	3000 1000	15 7
2	3000 1000	15 7
3	3000 1000	15 7
5	3000 1000	15 7
7½	3000 1000	15 7
10	3000 1000	15 7
15	3000 1000	15 7
20	3000 1000	15
25	3000 1000	1
30	3000	1
40	3000	1
50	3000	

in the

long run



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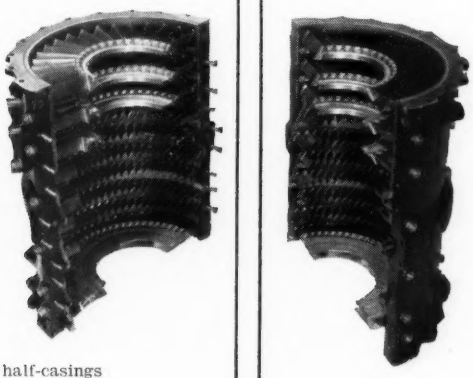

Compressor half-casings
Cast in ZT1 alloy
Fully machined weight 10½ lb each
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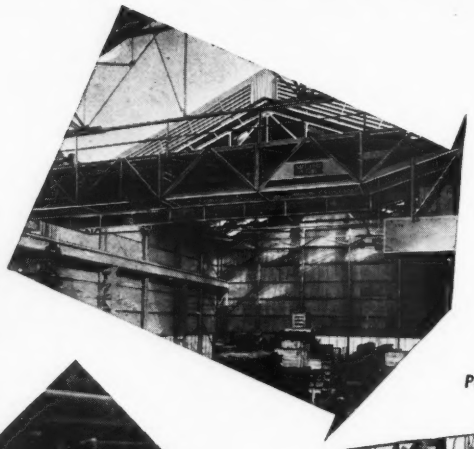

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Push Bar Conveyors

The movement of materials and products through the plant from goods inwards to despatch is a factor that costs time and money, unless proper use is made of mechanical handling equipment.

Paterson Hughes have a background of experience in every industry which enables them to supply the best scheme to suit any application.

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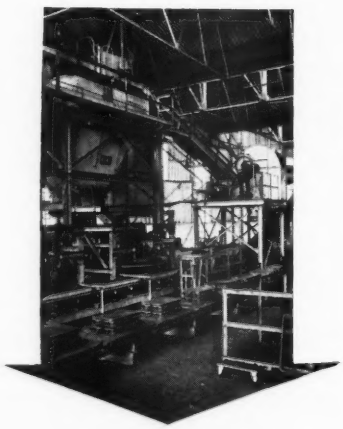

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meet the milling, drilling, and boring needs of the modern heavy machine shop.

The range includes machines from 2 in. spindle up to 10 in. spindle. The HRG type illustrated has a 4 in. spindle and is an extremely popular and versatile machine for medium capacity work.

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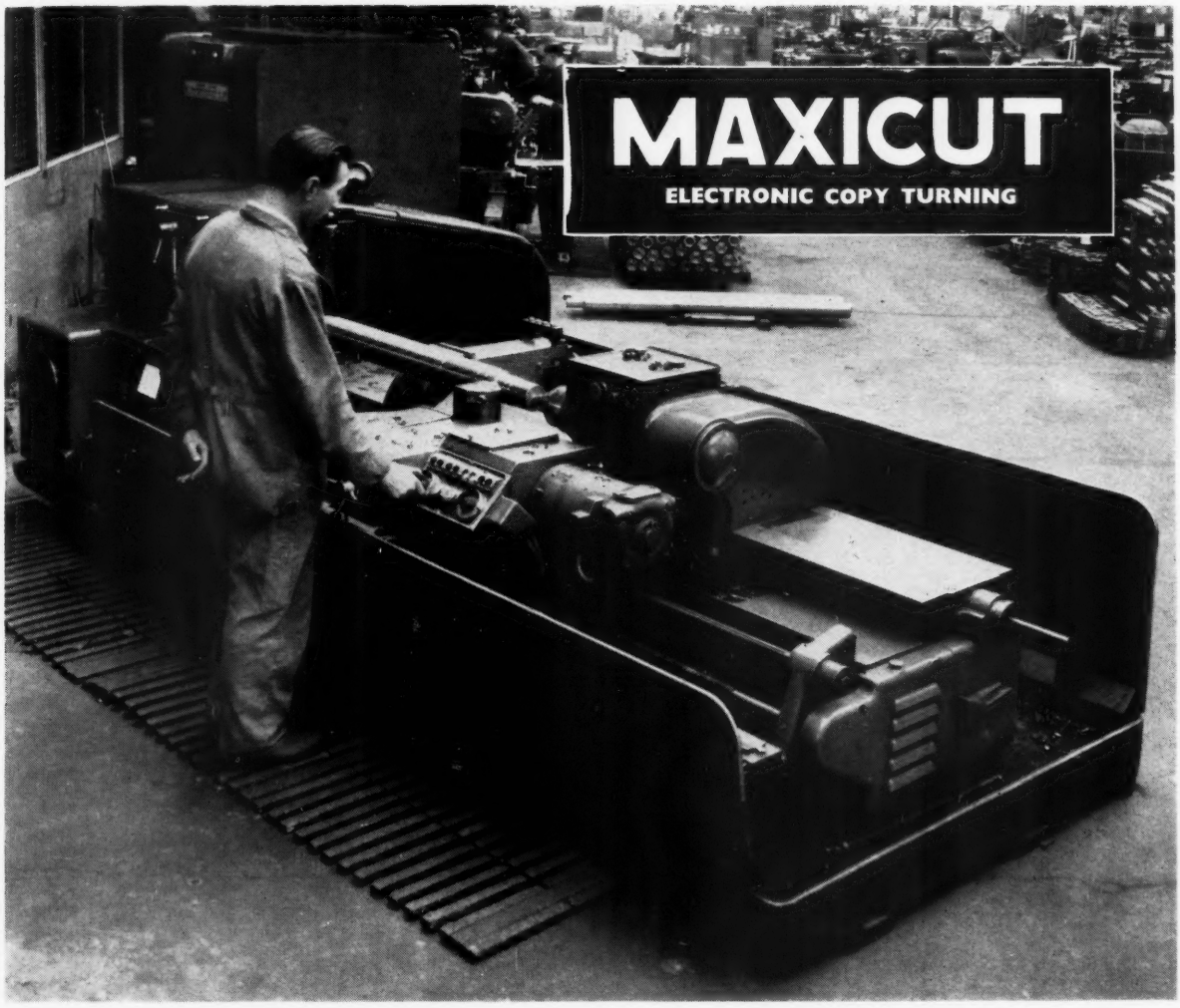
S211



simplifies and speeds up production of large multi-diameter shafts

The illustration shows a " Maxicut " at the Meco Works, Worcester, of the Mining Engineering Company Ltd., where it is demonstrating big savings in time and cost. If you have work of a similar nature involving profiles, tapers, etc., whether internal or external, it will pay to investigate " Maxicut " production.

This robust copy turner incorporates a heavy duty back slide, independently controlled, which can be employed for bulk metal removal, and several rear tools can be used.

Made in a range of sizes as shown in the table opposite. Write for full details today.

GENERAL SPECIFICATION	
Available with four bed lengths to accommodate between centres	18in., 30in., 42in. or 78in.
Maximum swing over bed	18in. or 22in.
Maximum swing over slides	11in. or 14in.
H.P. of main motor	20/20 h.p. 2 speed motor at 720/1460 r.p.m. 20 h.p. single speed motor at 1460 r.p.m. 35 h.p. single speed motor at 720 r.p.m. 40 h.p. single speed motor at 1460 r.p.m.

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D.223

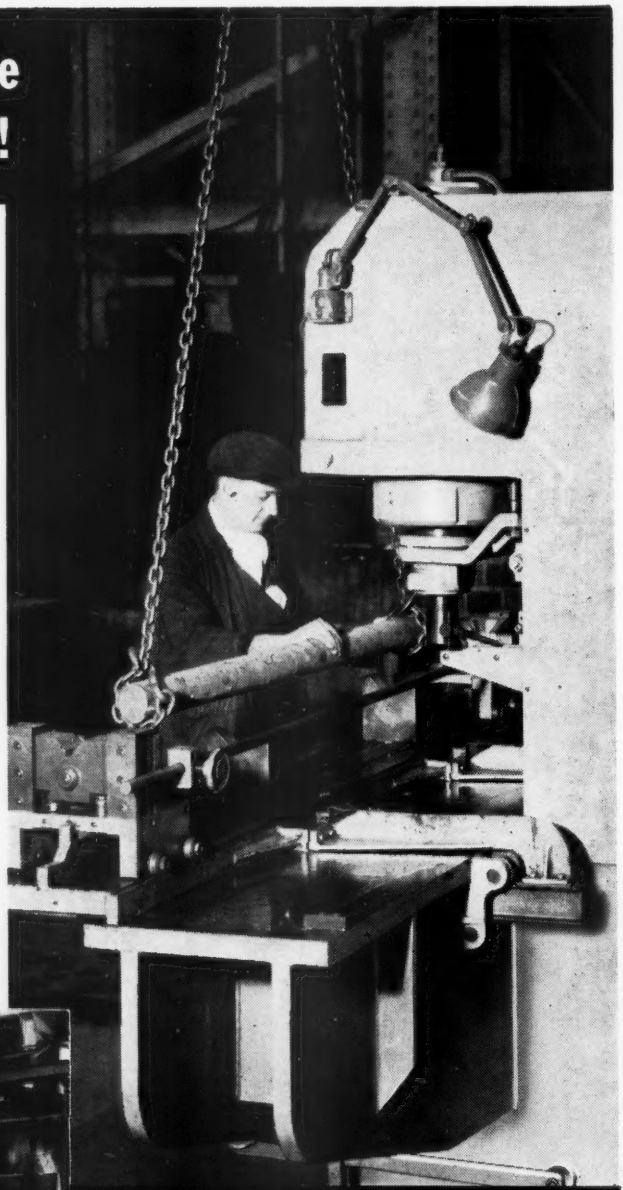
Load and unload outside the throat of the Press!

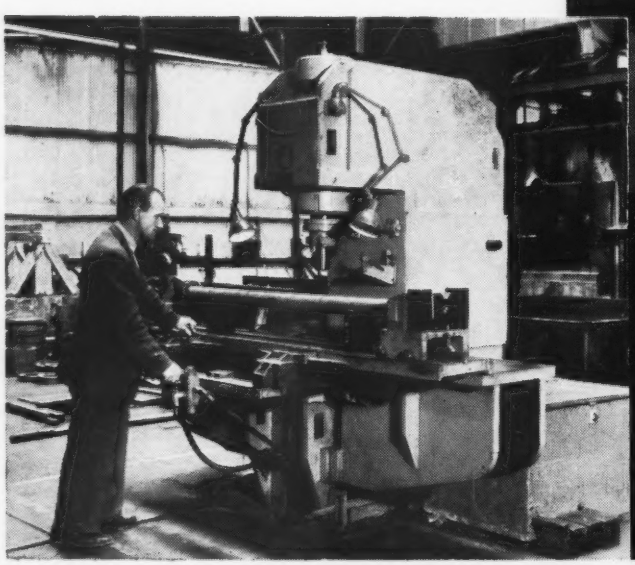
This 75-ton Hi-Ton Straightening Press incorporates a hydraulic traversing table for loading and unloading outside the throat area of the machine.

The illustration opposite shows the table in its forward position, and loading is simplified and speeded up with a minimised risk of damage to the machine by heavy bars and lifting tackle.

The lower illustration shows a bar in position ready for straightening and the operator is depressing the lever to actuate the hydraulic return of the table to its rear position with the component beneath the ram.

Write today for details of this type of Straightening Press and mention the capacity which interests you.





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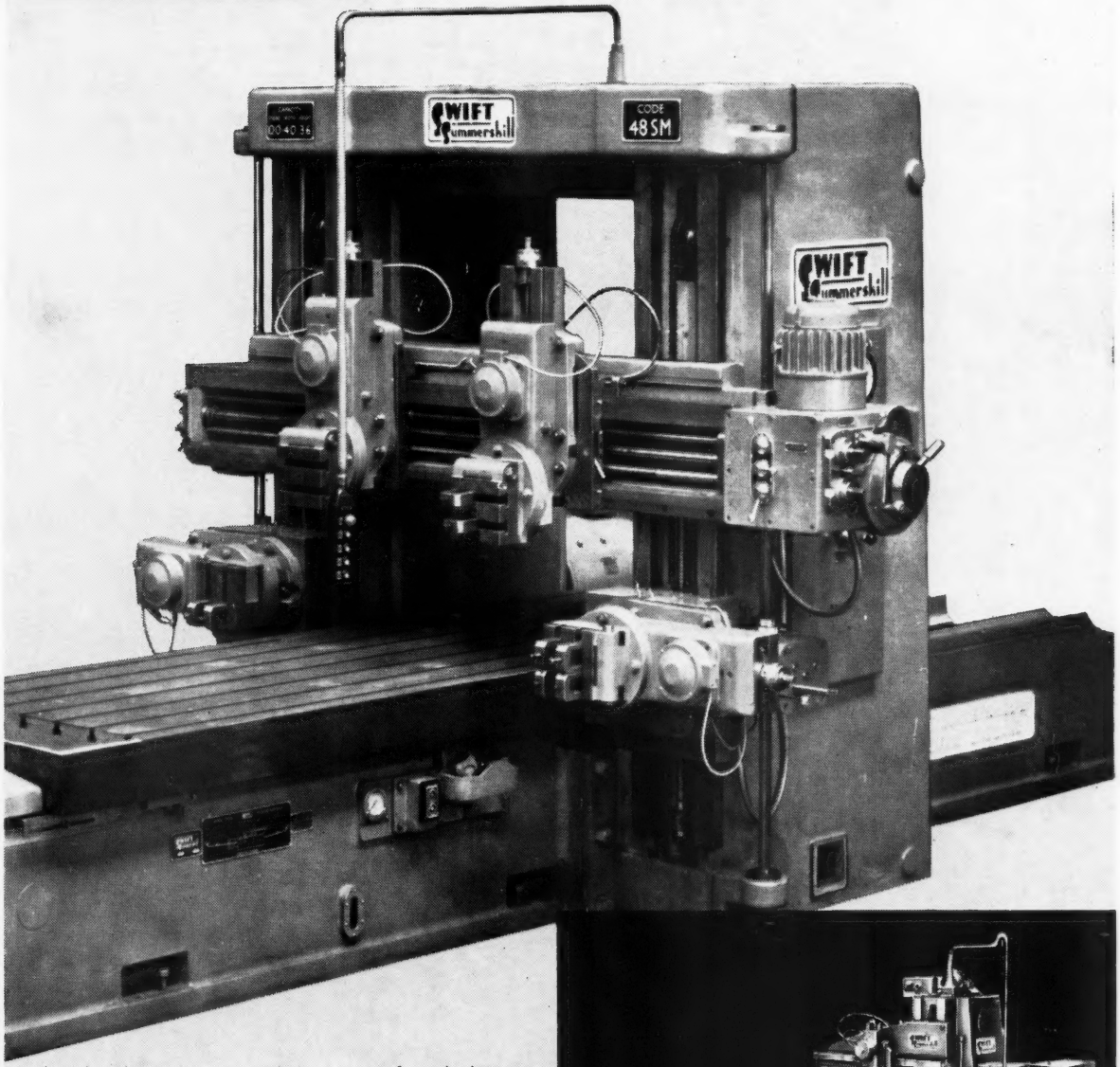
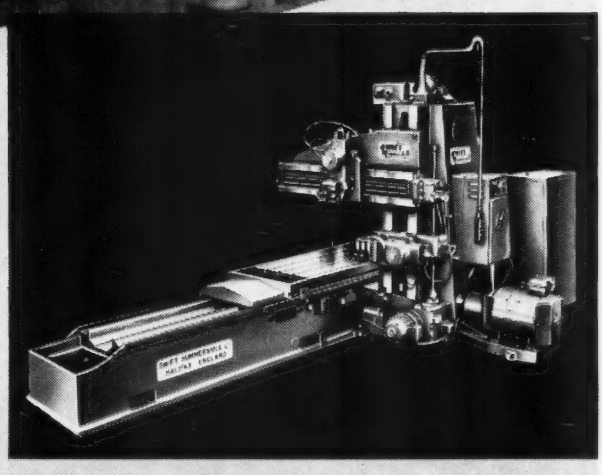
SWIFT Summerskill

All-Electric Planing Machines





Double column types are made in a range of standard sizes with width between columns from 2 ft. 6 in. up to 7 ft. and height under cross rail 2 ft. up to 6 ft. Openside Planers are available for width 2 ft. 6 in. up to 4 ft. and height under cross rail 2 ft. up to 3 ft. 6 in. Ward-Leonard type drive is employed and the standard range of speeds, cutting and return, is from 25 to 200 f.p.m. Feeds from 0.005 in. to 0.450 in. for the larger machines and 0.005 in. to 0.350 in. for the smaller machines can be obtained in increments of 0.005 in.

Write today for further details, mentioning the type and approximate capacity which interests you.

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DIAMOND *cut* DIAMOND

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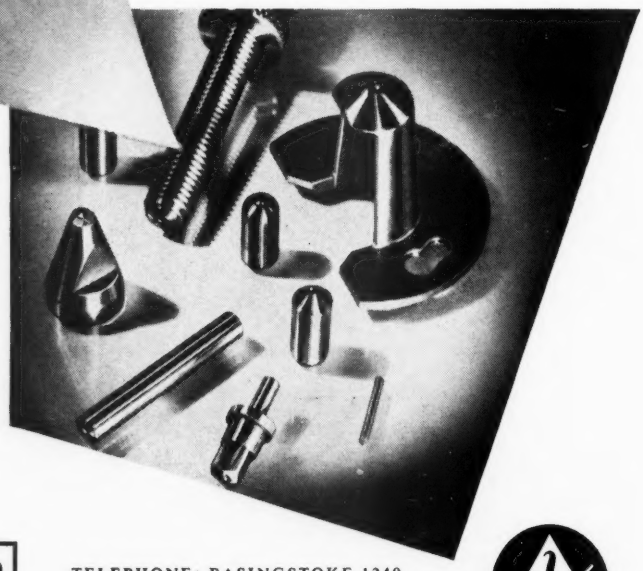

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J.W.4

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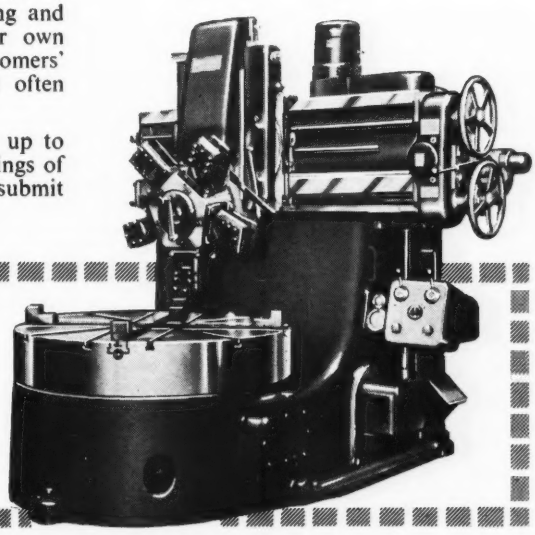
We pride ourselves at Webster and Bennett that we know most of the answers when it comes to boring and turning, and our customers agree. In fact, our own "puzzle corner" is always busy translating customers' drawings into machinable possibilities, and quite often remarkably favourable floor-to-floor times result.

If you have to machine castings and forgings up to 80″ swing, perhaps we can help *you*. Send us drawings of your components; our technicians will be glad to submit production proposals.



A standard Webster and Bennett Boring Mill with 60″ Chuck, admitting 35″ under the turret and 24″ under the cross-slide

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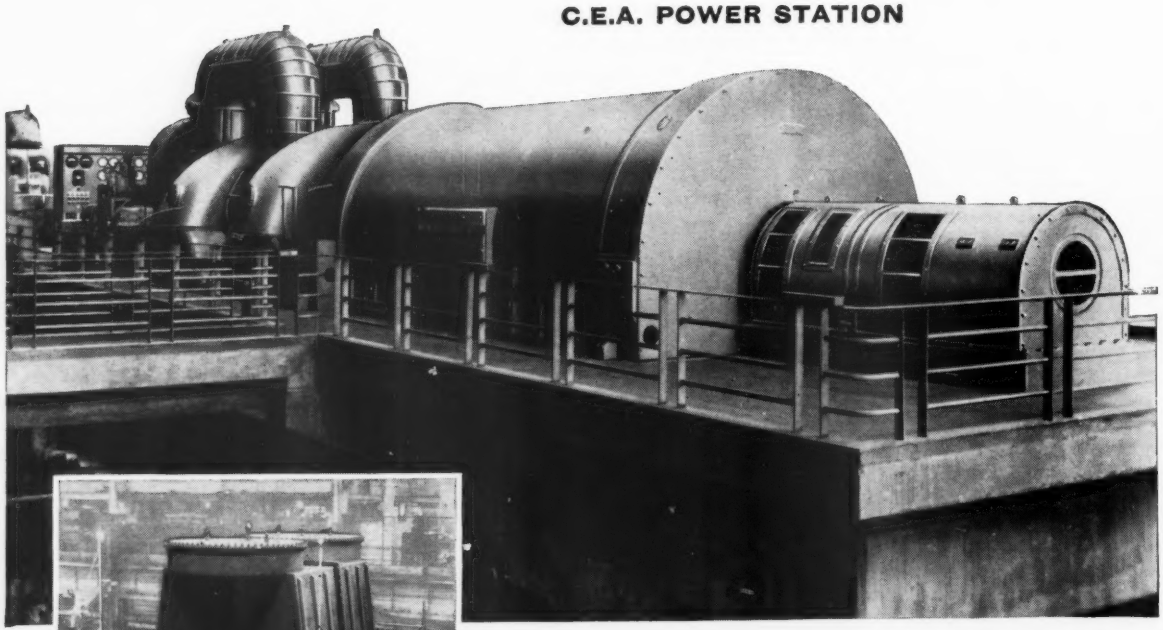
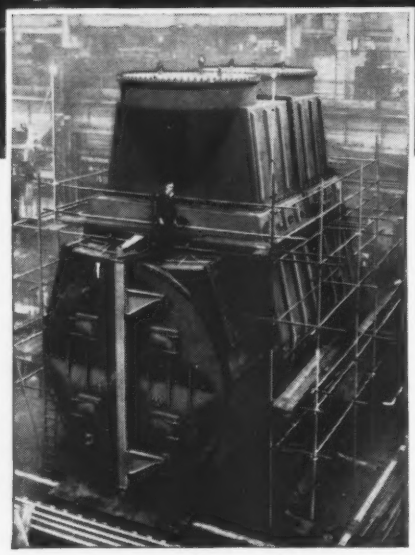
Power for the Grid–Portishead 'B'

C.E.A. POWER STATION





Metropolitan-Vickers are to supply six 60 MW steam turbine-generating sets to the C.E.A. Portishead "B" Power Station. These two-cylinder close-coupled steam turbines drive 75 MVA hydrogen-cooled generators, and the first two sets are now in service. The turbines are suitable for two-shift operation and are direct-coupled to the generators, which produce 50 cycle, 3-phase current at 11,800 volts.

The turbines have initial steam conditions of 900 psig, 900°F, and exhaust to single-shell central flow condensers which, in this station, have to be installed some 69 ft. below the turbines. The condensers, together with the five-stage feed water heating equipment are also being supplied by Metropolitan-Vickers.

The illustration shows a single-shell condenser under construction. Six of these units, each having a cooling surface area of 60,000 sq. ft., are being supplied for the installation.

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ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

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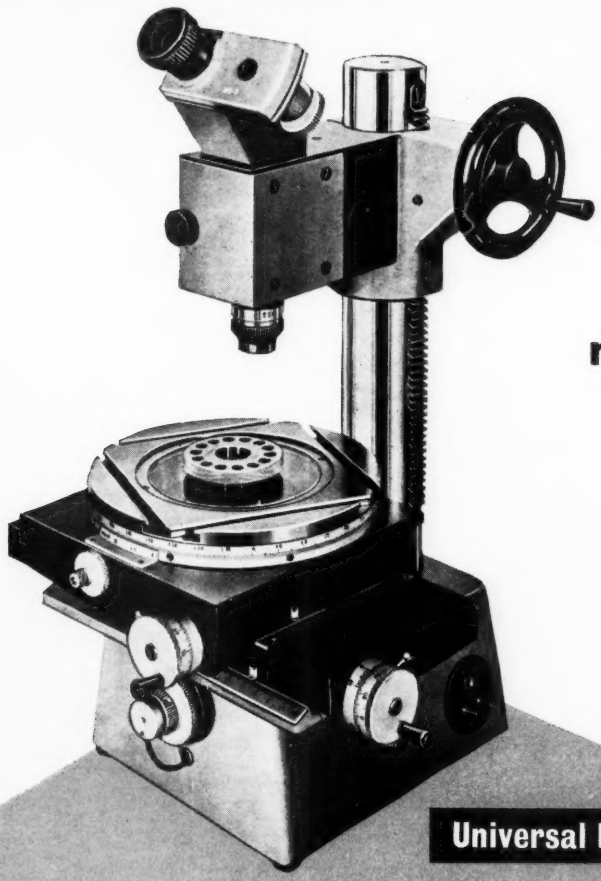

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Precision-built, versatile and mobile, the U-10 Measuring Support with its wide range of accessories brings to even the smallest workshop the assurance of speedier, more accurate inspection of machined parts.

Universal scope The U-10 Support is used for measuring flat and cylindrical parts, balls and diameters of threads by comparison with a standard or reference gauge. Accessories permit inspection of angles and thread profiles, vertical measurement in absolute value and measurement in rectangular and polar co-ordinates in a horizontal plane.

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Others are:

MUL-1000, MUL-3000 and MUL-4000 Universal Measuring Machines of 1, 3 and 4 metre linear capacity.

MUL-250 Shop Gauge Measuring Machine.

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Detailed information about SIP Measuring Machines is available from Société Genevoise Ltd., Newport Pagnell, Bucks.
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Measuring Machines by SIP

the Measure of Measures

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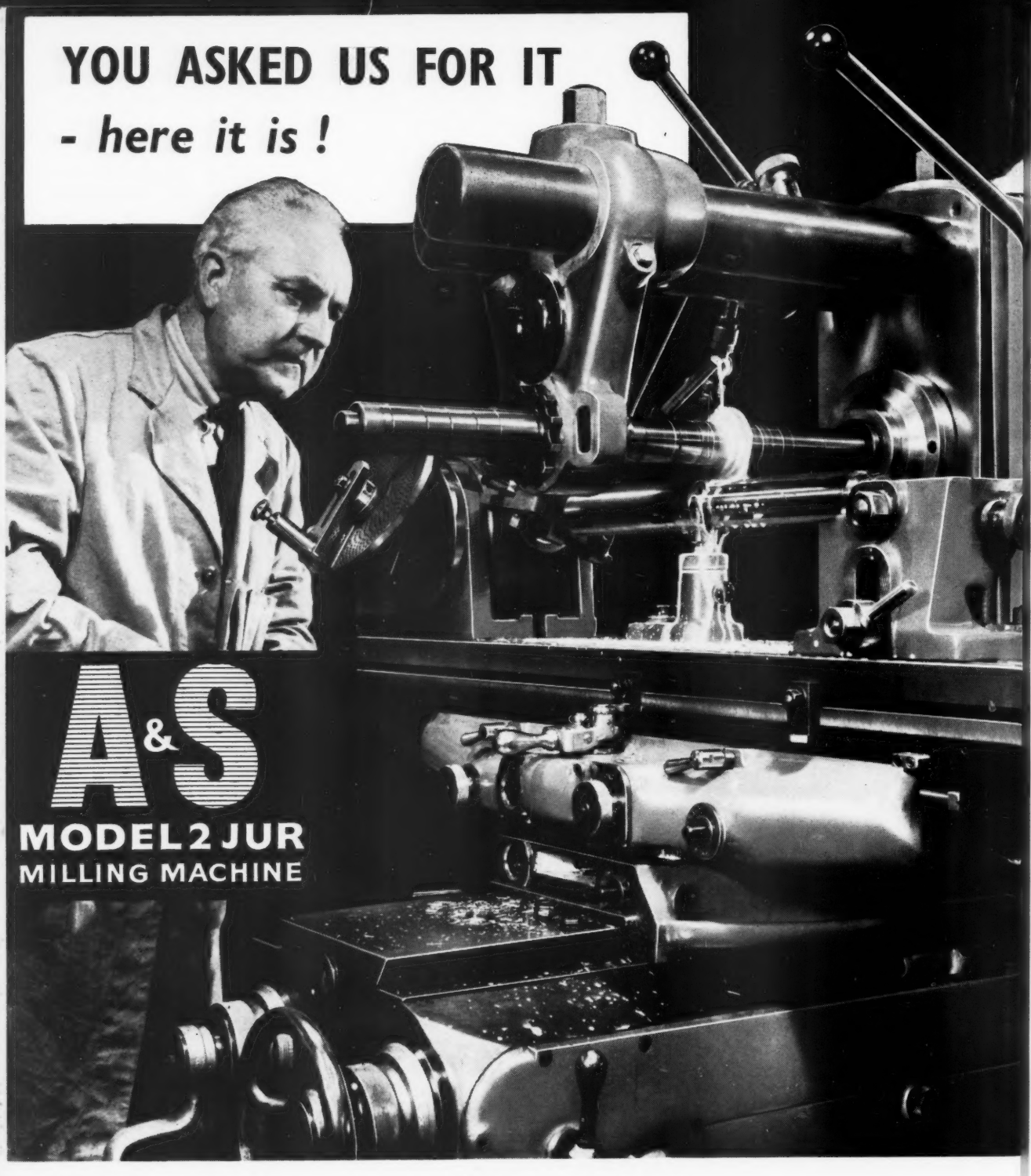

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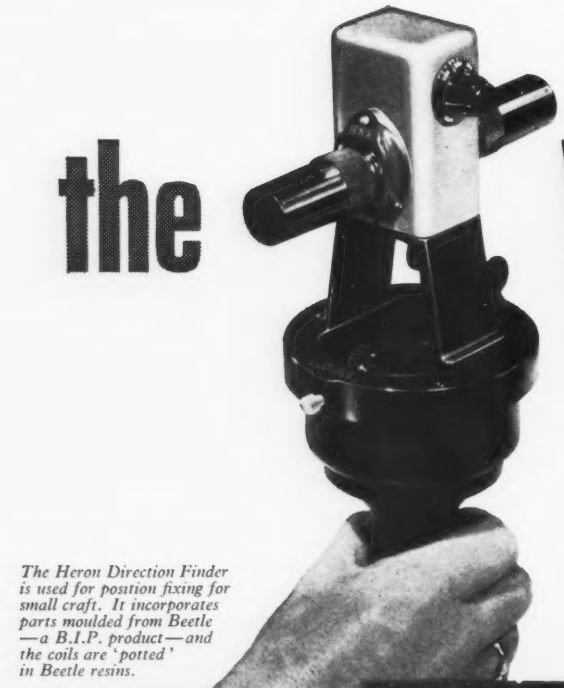

The Heron Direction Finder is used for position fixing for small craft. It incorporates parts moulded from Beetle—a B.I.P. product—and the coils are 'potted' in Beetle resins.

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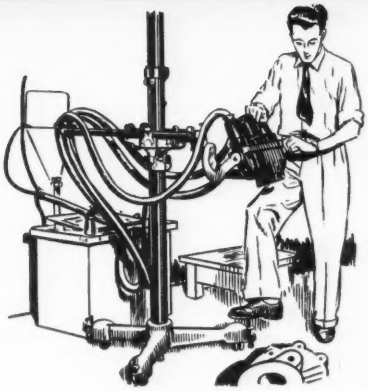

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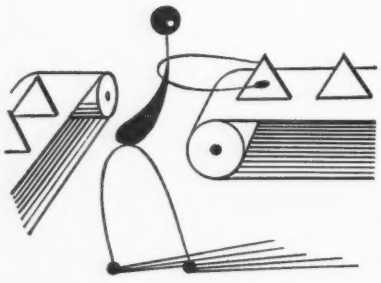
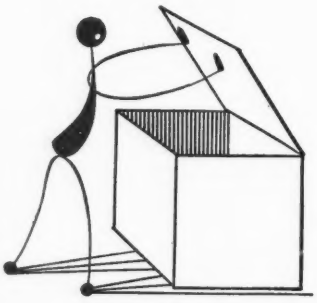
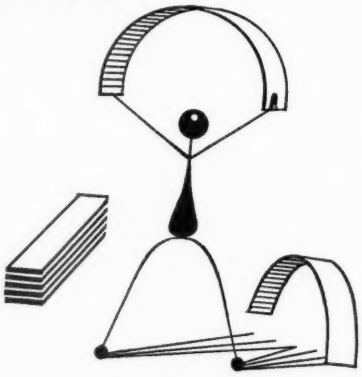


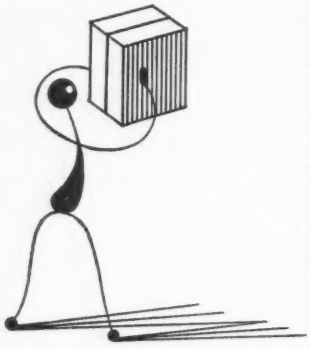
...transfer...



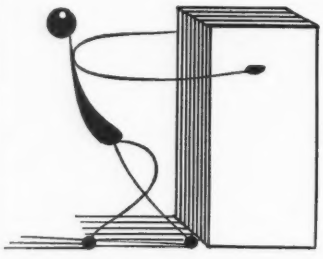
...open...



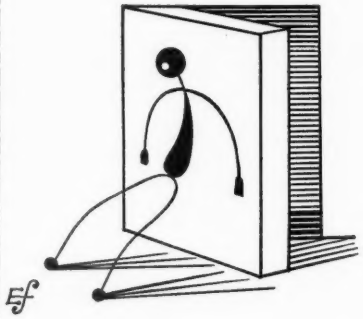
...bend...



...clamp...



...pull...



...close...

... roll, clean, sort, lift, turn, grasp and shelve. Hymatic Automation is thus invaluable in the automatic and selective transfer of parts from one process to the next, from conveyor to conveyor; in unloading one machine and loading the next; or in quick clamping to hold parts during machining. All designs of Hymatic Automation are made for specific tasks but are readily adaptable to others.

Hymatic Automation covers the whole problem—the design of the circuit—the machine—the means of control.

Hymatic Automation, therefore, has a place in your programme of productivity improvement.

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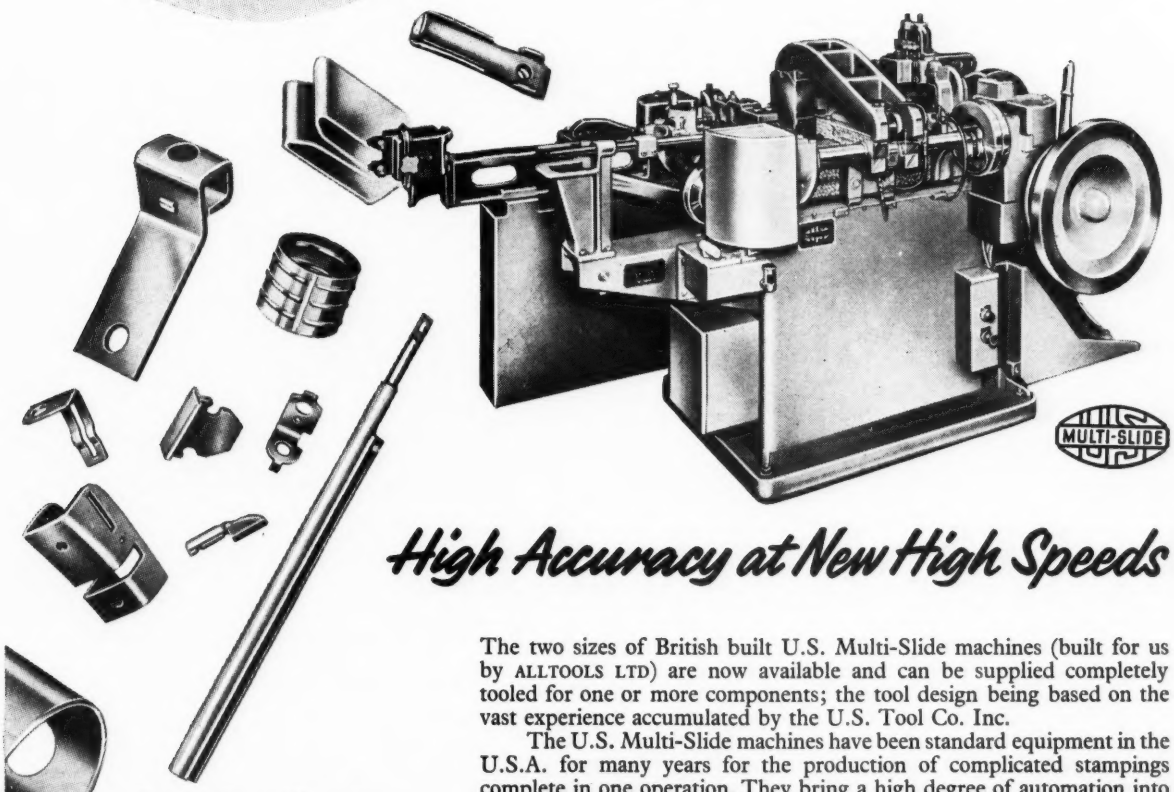

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The U.S. Multi-Slide machines have been standard equipment in the U.S.A. for many years for the production of complicated stampings complete in one operation. They bring a high degree of automation into every press shop and are indispensable for the economic and accurate production of many components used in Automobiles, Office machinery, Radio & Radio Valves, Television Receivers, Electrical and Electronic devices, Hardware, Locks, Razors, Book-bindings, Household utensils, Bearings etc.

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Send for illustrated leaflets, *also ask to see film* showing operation of the machine and examples of components produced. Our Sales Engineer will be pleased to call on request.

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Length of Feed	8"	12½"
Maximum Width of Stock	1½"	3"
Maximum Thickness of Stock	1/16"	3/32"

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Size of Face Plates	7½″ dia.	(190 m/m.)
Size of Centres	No. 2 Morse Taper	
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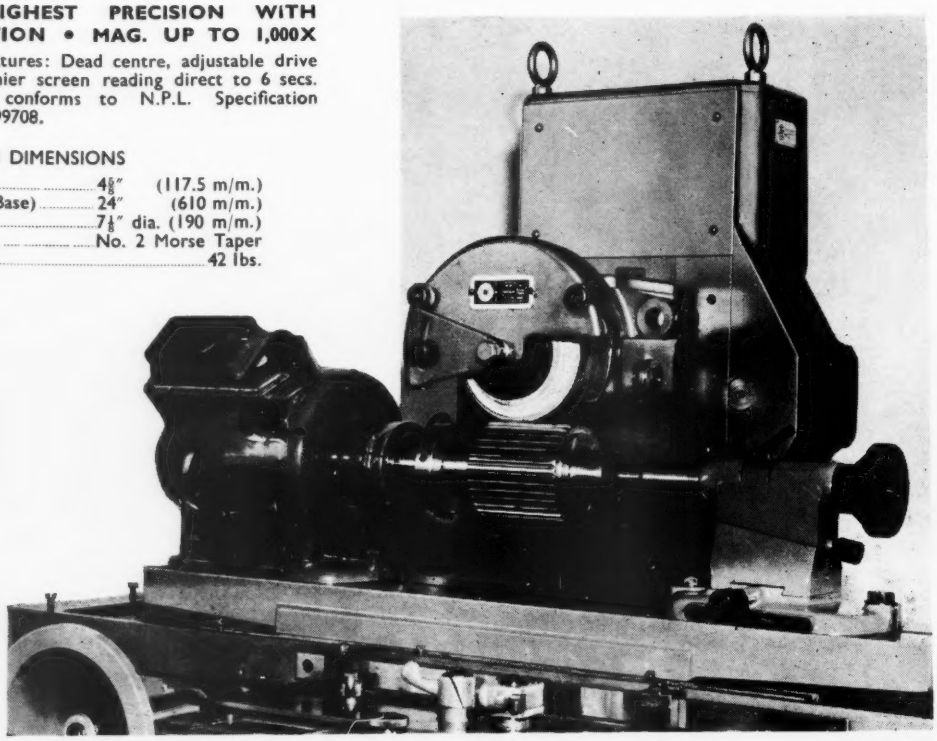

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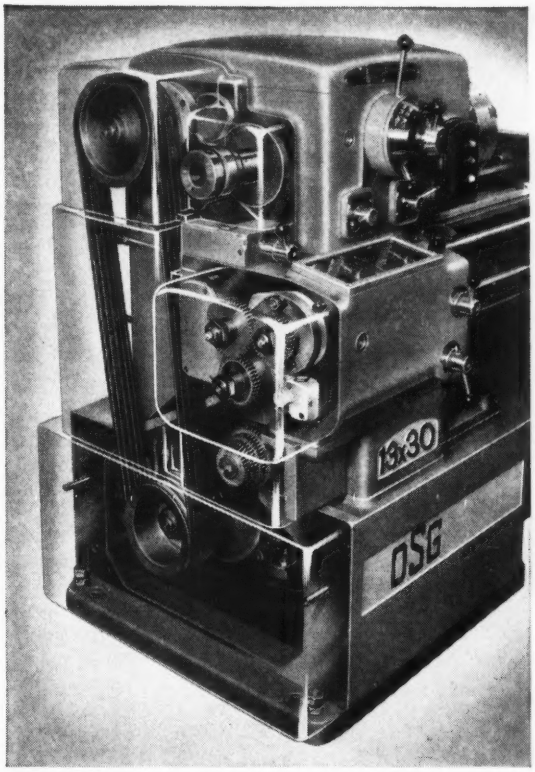
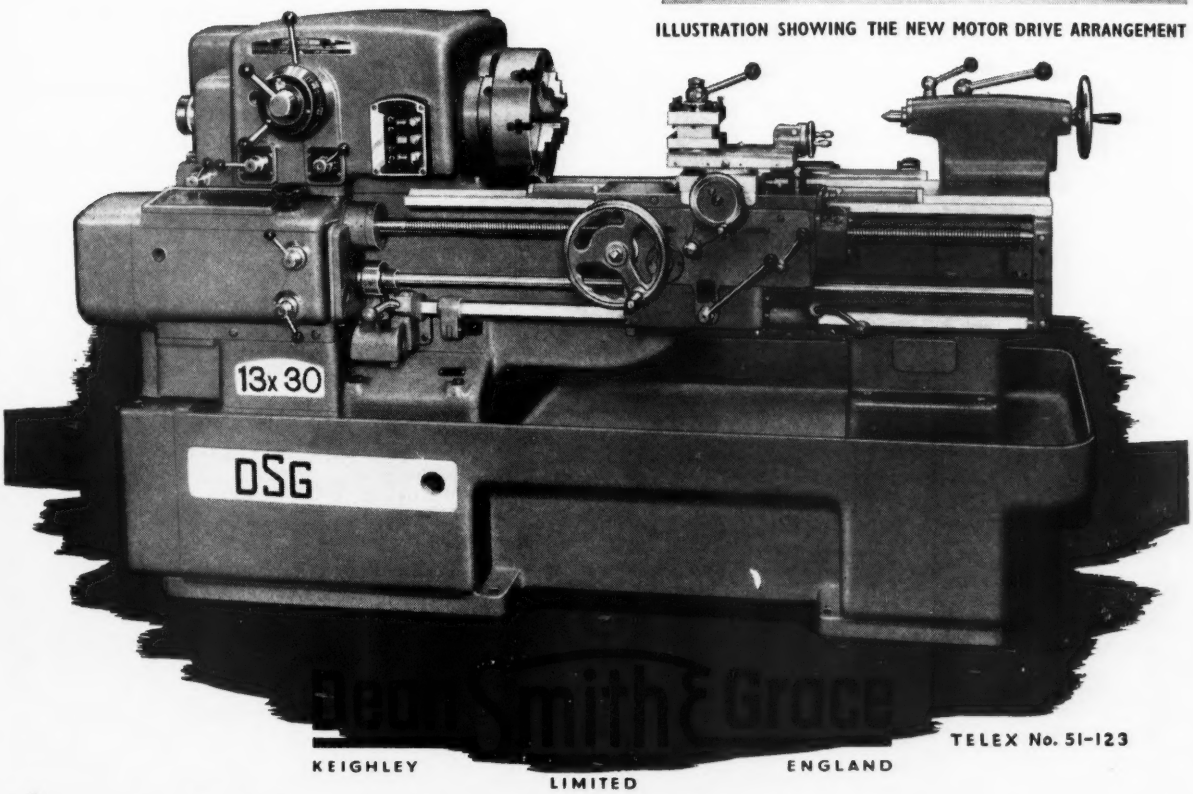


ILLUSTRATION SHOWING THE NEW MOTOR DRIVE ARRANGEMENT



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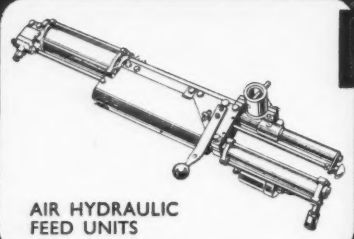

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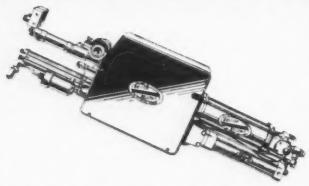

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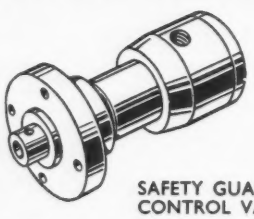

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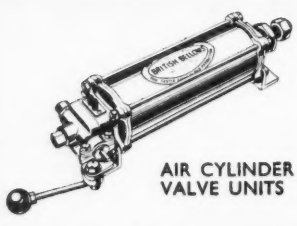
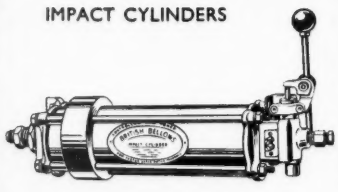
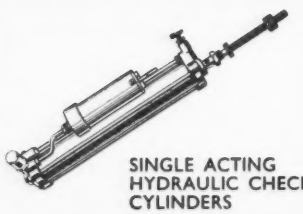


AIR CYLINDER VALVE UNITS

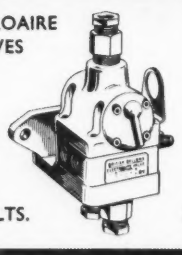
IMPACT CYLINDERS



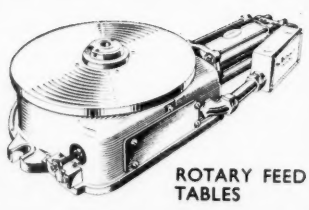


SINGLE ACTING HYDRAULIC CHECK CYLINDERS

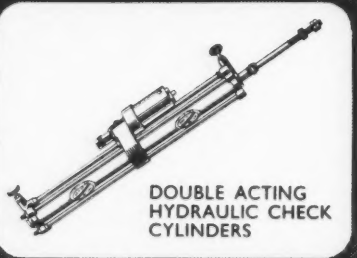
ELECTROAIRE VALVES



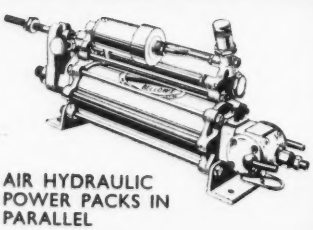
8 VOLTS. 3 SIZES



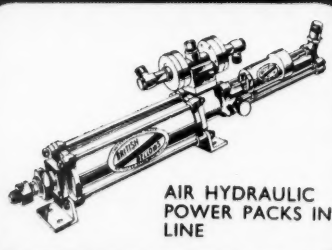
ROTARY FEED TABLES



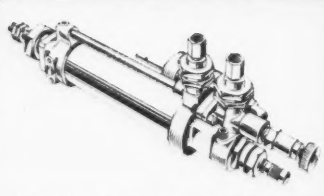
DOUBLE ACTING HYDRAULIC CHECK CYLINDERS



AIR HYDRAULIC POWER PACKS IN PARALLEL



AIR HYDRAULIC POWER PACKS IN LINE



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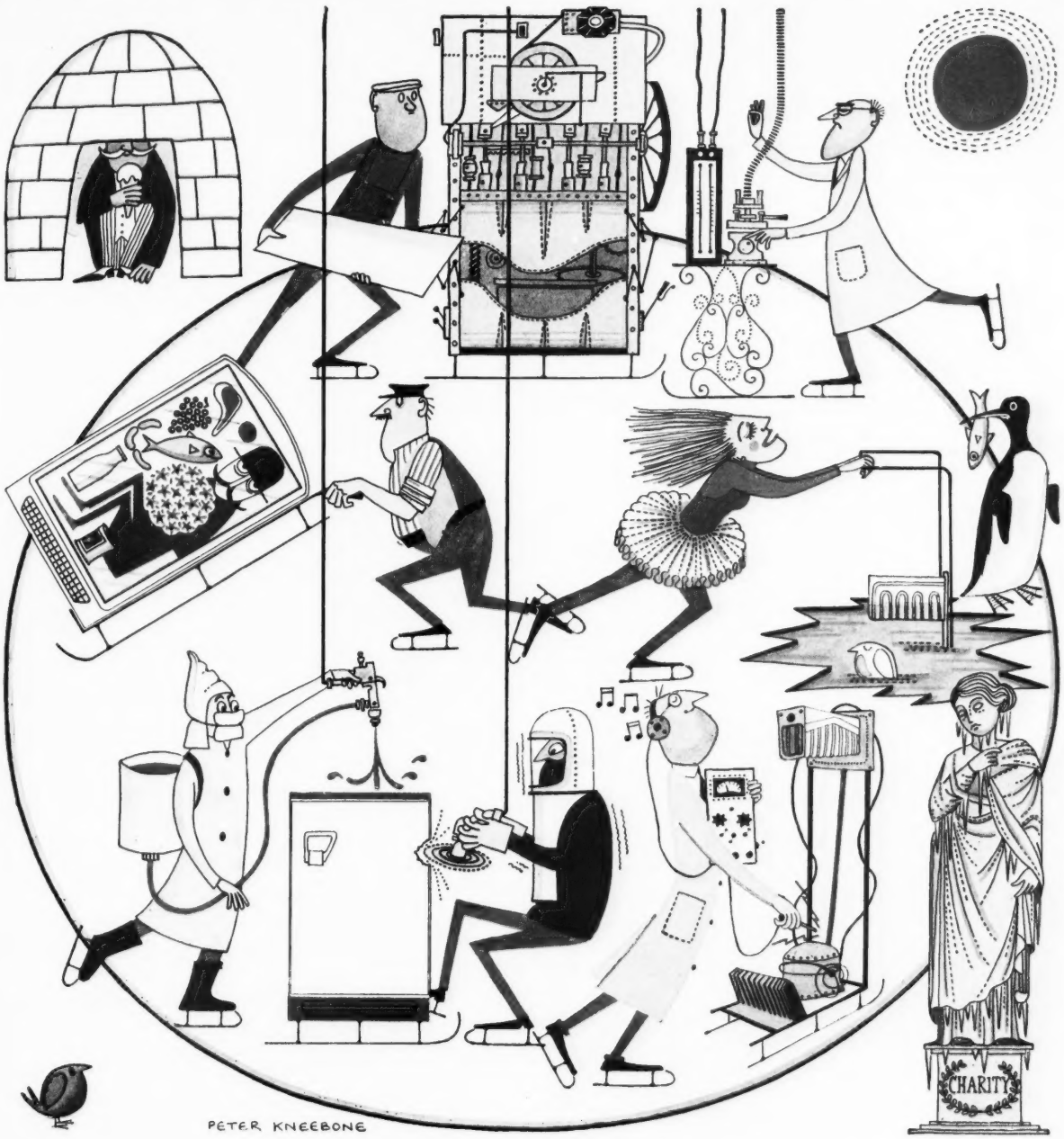

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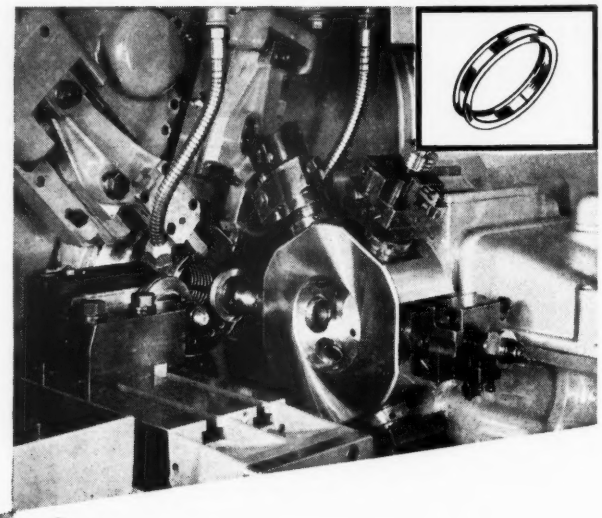

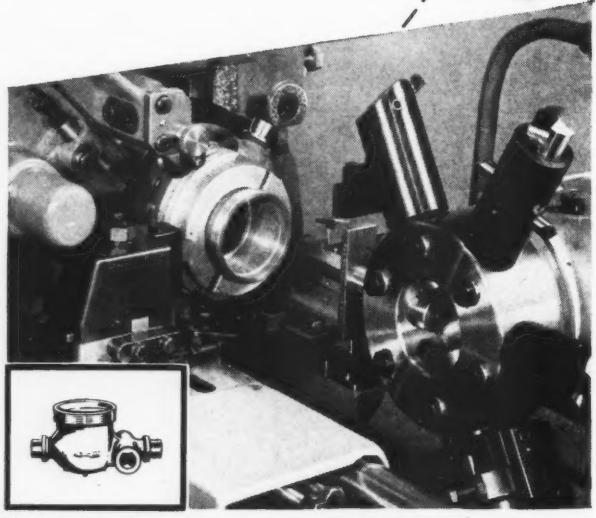

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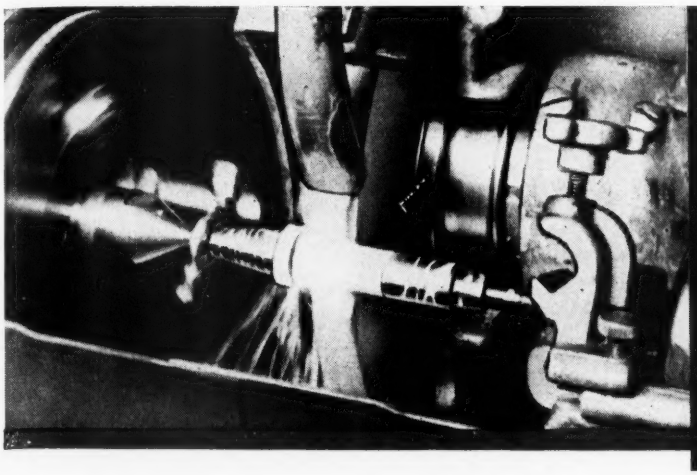

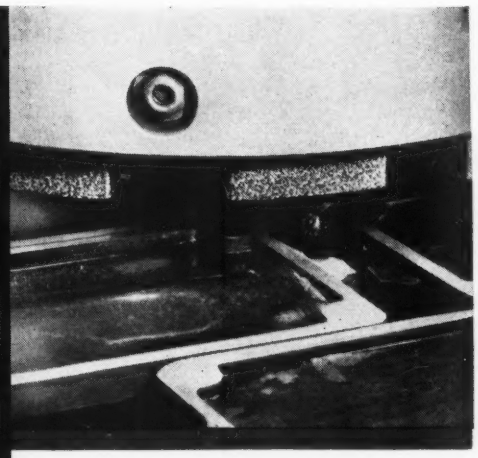

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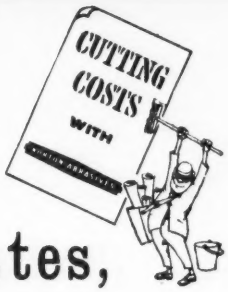

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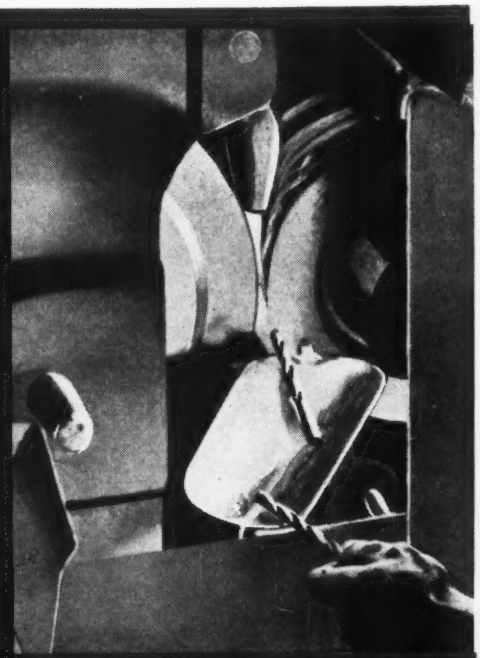

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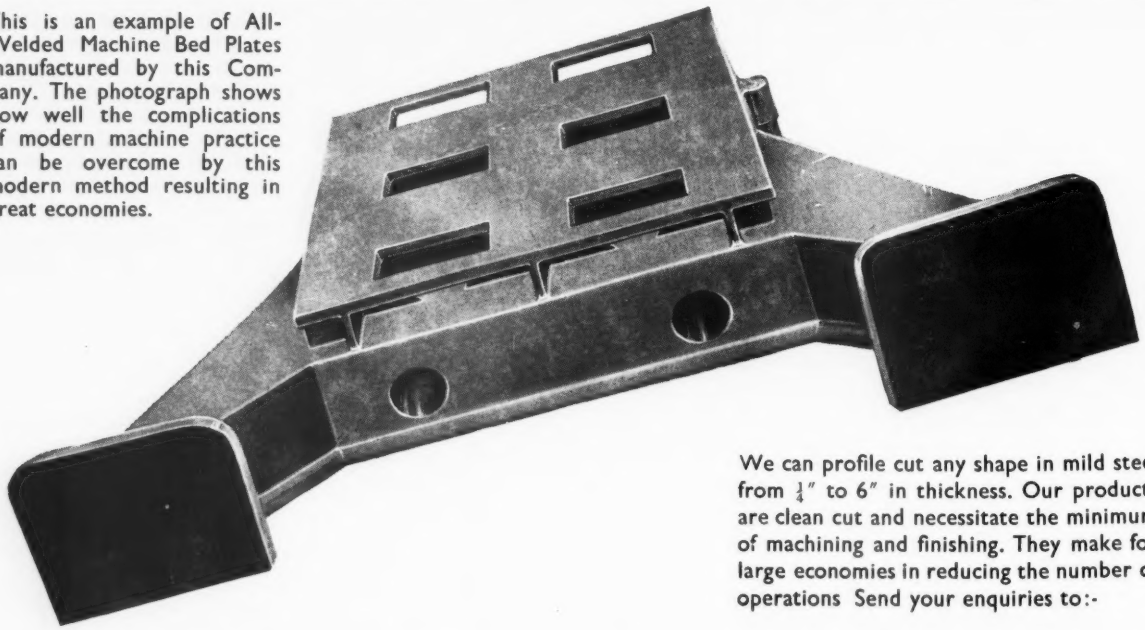

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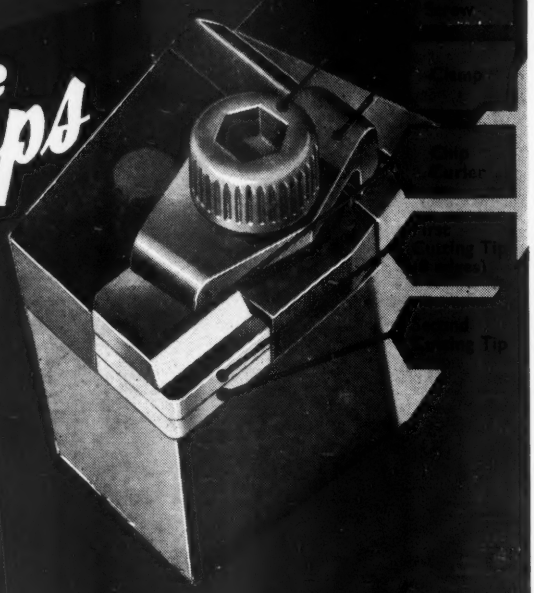

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The Institution of Production Engineers Journal
VOL. 36 NO. 7 JULY, 1957

A Presidential Message

from The Rt. Hon. THE EARL OF HALSBURY,
F.R.I.C., F.Inst.P., M.I.Prod.E.

THE Council of the Institution of Production Engineers having honoured me by nomination to the Presidency, I would like to take an early opportunity for thanking them and all concerned with my election to this high office and for the confidence they have shown in me.

The President of the Institution is neither a figurehead, on the one hand, nor the Institution's Chief Executive Officer, on the other; the latter position is the prerogative of the Chairman of Council. The President's function is more to focus the attention of both members and Council on a few outstandingly important matters of policy and to use the opportunity provided by invitations to attend meetings and banquets of local Sections to ensure their discussion. Like the constitutional head of a state, his prerogative is to encourage and to warn while preserving neutrality in respect of such policy decisions as emerge. In the last resort, it is for the members of the Institution themselves to make of it what seems good.

Clarification of Objectives

The most important issues currently before the Institution seem to me to require a clarification of its objectives and the status that will give them best effect. In the United States a mechanical engineer of sufficient seniority in his profession, and with a sufficiently wide experience of line-production and factory planning to practise as a consultant, will call himself a 'production engineer'. In the United Kingdom we seek to establish 'Production Engineering' as a profession by standardising an educational curriculum best suited for the training of those who may be consultants one day, but will more certainly occupy senior positions in industry. It follows that the minimum qualifying conditions for both Associate Membership and Membership of the Institution may be met by those having lesser industrial seniority than that of a mechanical engineer in the United States at the moment in his life when he would first describe himself as a production engineer. In what respect, then, should the educational curriculum of a British 'Production Engineer' differ from that of a 'Mechanical Engineer' in the professional sense?

Part III of the Institution's Examinations is one aspect of the answer to this question, but its existence raises a number of other issues which seem to require clarification. It is necessary to bear in mind that the Institution is not alone in

paying attention to the subjects of which knowledge is required in Part III. Professionally there exist the British Institute of Management, the Institute of Personnel Management and the Institution of Works Managers. Socially and politically there is the British Productivity Council. Academically there are numerous schools of Economics, and less numerous schools of Psychology, Sociology and Industrial Administration.

Professionally and academically is Part III to be thought of as a substitute for a wide range of disciplines, each the proper subject of whole time study, or is it intended to prepare the future production engineer for future collaboration with colleagues in these other walks of life? Socially and politically is it the function of the Institution to undertake propaganda intended to promote higher productivity, this being the proper concern of the British Productivity Council, or should the Institution limit itself to collaboration with that Council so as to provide it with the necessary engineering background? These matters carry important practical implications. Should the Institution run its own 'line' at conferences of its own convening or in reports of its own editing, or should it seek to organise joint conferences with other bodies on matters not exclusively concerned with engineering as such?

Broadening the Base

A second set of issues concerns the distinction between broadening the Institution's basis and opening its membership. In the chemical and physical professions there is a sharp distinction between the learned societies—the Chemical Society and the Physical Society with an open membership on the one hand—and the professional institutions with a qualification for membership on the other hand —the Royal Institute of Chemistry and the Institute of Physics. The engineering professions have not emphasised any similar dichotomy and have become the vehicle for the organisation of learned discussions and the exchange of technical information at what are virtually open meetings. They have maintained the distinction, however, between an open meeting and an open membership, and if the Institution of Production Engineers is to maintain and advance its professional standing it must perforce do likewise.

Broadening the base must not mean reducing the standard of professional qualifications. The justification for the existence of specialised Institutions is to be found in the need to deepen education rather than to narrow it. Any concomitant narrowing is but the price paid for depth in a curriculum where the student-hours are confined to the total available in a three-year degree course or a five-year apprenticeship. How is the continual tightening of the educational standard required for corporate membership to be reconciled with the secular trend towards a broadened basis?

These are the matters which seem to me to require careful thought at the present time.

"Automatic Production – change and control"

CONFERENCE, HARROGATE, 30th June - 3rd July, 1957

The Papers presented at the Conference are being published in this and subsequent issues of the Journal. This issue contains the following :-

DISCUSSION GROUP A4

"The Cost of Automation" by F. T. Hunter, F.C.A., F.C.W.A.

DISCUSSION GROUP B1

"Computer-Assisted Production Control" by W. J. Kease.

DISCUSSION GROUP D1

"What New Skills Will The Future Demand ?" by C. B. Gibbs, B.Sc.

DISCUSSION GROUP D3

"The Analysis of Industrial Behaviour" by Professor R. W. Revans, Ph.D., B.Sc.

DISCUSSION GROUP A4

THE COST OF AUTOMATION

by F. T. HUNTER, F.C.A., F.C.W.A.

THIS Paper is an attempt to marshal a number of the problems which will arise increasingly in the future, as a result of the accelerated adoption of new manufacturing and control techniques described by the now popular word 'automation'.

It does not attempt to assess cost in terms of money, or men. It is suggested that present experience and knowledge does not, despite any claims to the contrary, permit broad generalisations of cost of any real importance to be made, and that much more experience and research will be necessary.

What does seem reasonably clear is that, as a broad generalisation, these modern techniques are profitable. That is, doubtless, a glimpse of the obvious in that design and management skills would not be being devoted to the subject were it not so, but what does not seem anything like so clear is just how profitable they potentially are. There are rumours that some of the developments announced to the world in stentorian tones as miracles, from which gold will flow in ever-increasing streams, have proved to produce mere trickles, and the proponents prefer not to discuss the subject.

However, it would seem unarguable that no matter what the opposition, manufacturing and control techniques will change rapidly in the next comparatively few years, and that more and more reliance will come to be placed on automatic means of initiating and controlling manufacture, and automatic means of carrying out a host of clerical and semi-clerical tasks.

A number of problems will arise, technical and managerial. Many of them will have a cost aspect, using cost in a broad sense of financial resources, manufacturing capacity, manpower, use or waste of acquired skills, and so forth, rather than a narrower sense of rates per hour, incentive bonuses, incidence of overheads, etc.

It would seem sensible that all managements should be thinking seriously about such problems now, and try to develop some broad lines of approach, rather than deal with them at the crisis stage.

It is, of course, true that many managements are thinking about them now and it would be foolish, and arrogant, to suggest otherwise. But there is a suspicion that some managements are still, perhaps, in the stage of initial excitement without realising that the changes in prospect are very far-reaching. It is easy to over-state the prospects, but it is equally easy to ignore them and be engulfed by the tide of progress.

The implications seem to be national and international, and this Paper has to a great extent discussed the cost problems from a national viewpoint rather than that of an individual concern. All levels from the managing director to the shop floor are involved.

It is possible that this Paper will mention points dealt with more adequately and in more detail in other Papers and, if so, apologies are extended to the authors of such Papers.

Broad definition

There are conflicting claims regarding the origin of the word 'automation'. There are conflicting ideas of what it includes.

It is, perhaps, early days for definitions of general acceptance based upon tested experience to have emerged.

The booklet "Automation", of the D.S.I.R., defines it as "all technical developments that make automatic production more possible".

Is this definition quite wide enough in its wording to indicate clearly that the developments such as computers are included? While these do not take part in production in the sense that they form part of a chain of production processes linked electronically or mechanically, they take part through the provision of vital and often complicated information necessary to highly automatic production.

Indeed, there would seem to be no reason why, in due course, there should not be a large, highly complicated, fully automatic factory in which the control and integration of the entire production would be carried out by an electronic computer. So far as the writer is aware, this has not happened yet but is it too far-fetched a concept? Almost certainly not.

Are we all to become men from Mars soullessly pressing buttons and gazing at dials? Sir Ben Lockspeiser in his preface to the D.S.I.R. booklet says "Automation will not make robots of us all. On the contrary it will demand wider knowledge, greater ability, and a higher degree of skill from worker and manager alike".

M. Louis Salleron, in his book 'L'Automation', suggests that a simple definition is "l'ensemble des procédés automatiques qui remplacent le travail de l'homme".

John Diebold says that automation is "a means of analysing, organising, and controlling the means of production to achieve the maximum utilisation of all the productive resources, mechanical and material as well as human".

There are many more, all perhaps having objections, all having much truth in them. One of the shortest is that of Peter F. Drucker: "The use of machines to control machines".

A trenchant comment from Sir Robert Barlow, Chairman of the Metal Box Co. Ltd., appears in his review to the shareholders on the March, 1956. Accounts. He says:

"So much nonsense has been talked and written on this subject that it may be worth while to state this Company's practical experience of it.

"The word 'automation' is used to cover methods whereby an article, in the course of its manufacture, is transferred automatically through a series of machines on which various processes are performed without manual intervention and often under the control of electronic devices.. This definition accurately describes the method by which the great majority of our metallic containers are now being made. It isn't new! The method has been in use in our factories for more than 30 years and most of our cans are now made by it at speeds up to 400 a minute. We expect very soon to operate such machinery at much higher speeds."

Scope of technical advance

It is frequently overlooked that there is, basically, nothing new in automation except the word itself. There has been a constant process of development for over 100 years at least. There have been periods when development was not fast, but other periods when the pace was furious and almost overwhelming.

The present shows all the signs of being one of the periods of furious and almost overwhelming pace. This pace has been accelerated vastly in the last very few years by the development of, *inter alia*, electronics, and ideas of how and how not to do things are changing very rapidly.

This Paper is concerned, therefore, very largely with the possible effects of this much accelerated pace of development.

The D.S.I.R. booklet already mentioned suggests that three main channels of technical progress will be pursued:

(a) An expansion of the scope of mechanisation by transfer-devices that link machine tools in automatic production lines, and by advanced techniques of handling materials and products and of assembling components.

(b) A rapid development of techniques of automatic control over manufacturing processes and their application to an ever-widening range of industries.

(c) The rapid and automatic processing of an increasing range of technical and business information by the electronic digital computer, with a consequent extension of automatic control to complex manufacturing operations and commercial offices.

The D.S.I.R. clearly include under the automation umbrella office work, as distinct from clerical functions necessary to control production functions. For example, a system of preparing packing schedules, despatch notes and invoices on a computer is automation.

Railways are another field where automation is being thought of and adopted. The French Railways are understood to have installed already considerable amounts of automatic control equipment, which govern the operation of trains over large areas with human intervention only at a remote control centre, and they, as well as the London Transport Executive, are talking seriously of the feasibility of running electric trains without drivers.

Many more examples could be cited. The point really being made is that automation is not just better and more rapid means of making things. It covers almost the whole field of human activity, and not only industrial activity. We accept, nowadays, as commonplace, cookers which turn themselves on and off, either to a time control or a heat control, devices which ring alarm clocks and pour out the morning cup of tea, thermostats, and others. They operate in accordance with instructions previously given to them, and subject to the fallibility of all devices, will continue more or less unaided until stopped. These are automation.

There is no doubt but that the lives of all of us are being, and will continue to be, affected drastically by these developments. While many may deplore an apparent enslavement to machines, and curtailment of individual liberties and choices, this is a view that has again and again been taken of progress of any kind. It is a view that the writer of this Paper suggests is completely erroneous, but, whether it is or is not, the revolution will continue and will prevail.

Paul Einzig in the preface of his book: "The Economic Consequences of Automation" says "It is of vital importance, not only from the point of view of our prosperity, but even for our survival as free nations, to proceed with automation with the utmost speed."

Capital requirements and resources

Does the accelerated pace of automation call for an increase in the annual rate of investment in fixed assets, and working capital, and if so, where does it come from?

There appears to be a wide divergence of view as to whether the capital requirement will be larger or not. The problem is not made easier by the obvious

fact that industries differ, and the truth in one may be a falsehood in the other.

Paul Einzig says that there is statistical evidence of a reduction in the value of fixed assets in comparison with the value of annual output. He points out also that an advance in the replacement of man by machine means more capital requirements and not less.

But is there any evidence yet of whether present trends will continue or be reversed ? Probably not.

In some industries new equipment is less costly than the old, in some it is much more costly, and a factor of importance is the reason for installing modern equipment.

It can be installed to reduce costs of production, thereby requiring less working capital for a given volume of output, or it can be installed to increase production, thereby requiring more working capital.

In 1954 in the United Kingdom £M2,500 was devoted to capital goods. This represented 16% of the gross national product. Will automation need more ?

In the highly automated chemical industry in U.S.A., evidence was given before a Congressional Sub-Committee that in 1954 the average amount spent on new equipment was $2,240 per production worker against an average of $877 for manufacture generally, and that the total investment was approximately three-and-a-half times per production worker compared with manufacture generally.

It would seem likely that for some time the requirements of capital will increase because technical progress will be rapid, and existing plants will become obsolete.

But there is reluctance on the part of industrialists to scrap plant and install new. If the concern is apparently both making good profits and facing a continuation of that happy state for some time ahead, it is asking quite a lot to expect a very ready adoption of a bold and comprehensive re-equipment.

There are, of course, the bold and farseeing who have no hesitation in spending handsomely on technical progress, but there are many who show marked hesitation.

A survey of the age of plants would probably show a surprisingly high average figure.

It would seem that, so far, the finance needed has come very largely from the resources of the various companies. The progress, while rapid, has not been all that rapid and companies have been able to cope with it. For the small concerns the position is, perhaps, more difficult and outside help is needed. Some of this cover will come from large customers prepared to finance a small but technically competent supplier.

The gross national product has risen by approximately 3% per annum since about 1946, and provided there is a progressive growth, there would seem to be no reason why an increase cannot be made in new equipment without damaging growth and investment in other things.

In general, it would seem that no difficulties of any real consequence should emerge to prevent industry finding the capital very largely from its own resources, particularly as after some time cheaper production should provide some of the increases necessary.

Machine tool resources

The machine tool industry has been working at pressure for some long time, and deliveries have been difficult. Any increased demand on them as a result of automation could probably not be satisfied to any significant extent without expansion.

But some of the demands will surely be in the form of substitution, new equipment to new designs taking the place of demands for the out-dated equipment.

To some extent also, machine tool plants themselves will adopt automatic techniques and achieve, after some time, greater production.

There is another factor of significance in that much of the equipment needed will come from plants which hitherto have not been in the machine tool field. Companies such as E.M.I. are developing, in conjunction with a machine tool manufacturer, control devices of various kinds. Much, therefore, of the demand will not fall on the machine tool industry itself but will be spread over other industries.

There are signs, also, that end-product manufacturers are, because of shortages and, perhaps, lack of technical know-how in the machine tool plants, starting to design and manufacture their own plant. Much of this will, no doubt, be done on a trial and error basis which almost determines that the experimentation and working out of the final set-up are often better carried out by the technicians and in the workshops of the user.

It is possible, of course, that increased demand for the end-products will lead to expansion of manufacture and a demand for much more plant. If this happened too rapidly there would be, no doubt, serious shortages and a general slowing up of the rate of expansion, until the machine tool industry had expanded correspondingly.

While engineering represents a very large part of industrial activity, however, it is by no means in advance in automation. Flour milling, refining, chemicals, to mention a few, are far ahead. It is easy to worry about the machine tool industry, but much of the present demand for plant falls on people whose use of machine tools is not so great. The manufacturers of highly automated plants such as milling and chemicals have less scope themselves to install and use effectively in their own works a high degree of automation. The demand for automatic control gear falls on the electrical equipment industry, for example, and even today much of their work is done by hand.

While this sort of pattern will very probably change, and the engineering side will speed up, there are grounds for thinking that the rate of speed-up will not be alarming and that the various concerns will be able to satisfy the demands at least as well as now.

There are some who express the view that, apart from mammoths such as the motor car companies, factories will tend to become smaller and demand less equipment, because the rate of production will so increase as to satisfy all possible demand from less

equipment. The development of more shift working which is a result most likely to flow from automation will have this effect. Plants will be able to operate almost day and night without incurring some of the additional costs and problems which have bedevilled shift working in many industries in the past.

But perhaps it will be found to wear out more quickly, so that the situation is as before.

It is hard to see what the immediate future may be in terms of "cost". Will it be chaos for some time with a wild scramble, or will it be more orderly because expansion proceeds more slowly? As a guess, it is suggested that the latter is more likely, although there is not implied in that suggestion any belief in slowness as a good thing.

Management

It is difficult to separate the problems of management and manpower. There is a distinct probability of a general upgrading of required skills. More and more people will be required with more and more technical skills. Other Papers are discussing these problems in detail,

From the cost aspect it would seem most likely that the personnel needed to run a factory will be more costly because of a much higher standard of training and education.

Management will tend to pass into the hands of specialists, and these specialists will require a broader training in purely management techniques. There will always be such problems. The idea that factories will cease, for example, to have welfare problems because there is no one for whom to provide welfare is doubtless, quite feasible but at present, a long way off.

There will be:

(a) higher investment (in many concerns) in equipment;

(b) a closer integration of one process and another;

(c) an increase in manufacturing complication, if not in end-products.

All this requires increased experience, technique, breadth of vision, versatility, from the managers. They must take a great deal more interest in planning, methods, costs, and must understand more of general business economics.

It follows that staff such as accountants must understand much more of technical problems and methods. Technicians are going to find themselves much higher, in general, in the management hierarchy.

Something of the same kind will happen in offices, at least the large ones. More and more highly skilled people will be wanted.

Whether such people can be found (and there are views that the general level of intellectual ability will make it difficult) is, doubtless, dealt with in other Papers.

The effect on the cost of the product, however, should not be an increase. The greater volume of production should more than absorb total cost increases, giving a lower cost per unit.

Boards of Directors, however, will have to accustom themselves to thinking in terms of a more costly man.

In addition, the cost of training must go up in total, if not per man. Without being aware of the precise position, is the technical teaching space capable of absorbing many more students? Are there the necessary teachers available?

As a guess, the answer is no. If it is "yes" to the space, is it "yes" to the teachers? Broadly, it is suggested that much more must be spent in total on training, although experience, in due course, will enable more men to be put through per £1 of cost, just as more pieces should emerge per £1 of cost in an automated factory. This does not suggest an automated technical college, but the analogy is, surely, sound.

Among the computer manufacturers, at present, a certain amount of general post seems to go on amongst the higher staff at least. This would argue a shortage, and if that is true, is it too cynical to suspect some degree of buying each other's good men at higher salary rates?

This point is a very important one. The need is obviously there, and will, at least in due course, be filled. Such needs almost always are. But Company A won't fill their need unless they are prepared to pay the going rate.

The competition for good men may well inflate rates artificially for some time, but permanent and justified increases in rates will undoubtedly take place.

What looks like finally disappearing is the old-style manager who worked by something called intuition (one suspected at times a little gazing at tea-leaves at 11 a.m. and 3 p.m.). That is, perhaps, not a cost to the nation at all, but a very positive gain.

As a matter of interest, advertisements have been appearing in U.K. journals for technical staff by American Companies. If the pace of advance is accepted as being greater in America, it would seem a reasonable inference from such advertisements that the shortage is already showing itself there and cannot be filled from their own resources.

Manpower

There is not much doubt that unions fear automation not only in this country, because of the possibility of redundancy, and there is some evidence that smaller firms have not adopted automation because they knew that the possibility of being able to reduce numbers was remote.

Is automation likely to be costly, in the sense of creating much unemployment? Some say yes, vehemently, some say no equally vehemently.

There is a possibility, perhaps, of temporary unemployment but there is not much sign, at present, of anything large-scale. There is, and has been, a shortage of labour for a long time, and despite some of the reports of recent months not much redundancy has shown so far.

A switch from some types of employment to others is most likely (e.g. many more people having opportunities to become higher-grade technicians), and some people will tend to become much more mere machine-minders.

This is good and bad obviously. An increase in high-grade technicians is good but the disappearance of craftsmen is bad. On the whole, the good will outweigh the bad. Classes of employee such as maintenance and services will increase.

The history of all Industrial Revolutions has been to raise the numbers gainfully employed, and no good reason seems to have emerged why the present revolution (if it can be called that) should not show exactly the same pattern.

Demand should be stimulated through lower costs and prices, which will lead to greater production and a demand for more people.

The evidence so far seems to show that firms adopting any degree of automation have not laid off people because :-

1. Natural wastage took care of some. (There is about one job change *per annum* per three employed in the U.K.).
2. Shortages have been made up in other spheres of the works.
3. Many firms have expanded.

Much the same picture is seen in offices. Though the degree of automation in offices is, probably not, so far, as extensive as even the little in manufacture, there does not seem to have been much redundancy. Indeed many types of clerical and semi-clerical jobs will increase tremendously. One of the most important tasks in automating an office is to carry out first some very extensive O. & M. work. This will demand an increasing number skilled in this kind of work.

Many people hope that one of the results over the years will be a reduction in working hours. This calls for more leisure pursuits, and leaving out the argument that few of us are qualified to make any real use of increased leisure, there would follow a demand for leisure services.

A point of some significance also is that the industries such as chemicals which are most suitable for automation are small users of labour.

To quote Sir Robert Barlow again, he says: "Over the period (i.e. some 30 years), and particularly during the last 10 years, automation has led to a transformation of our industrial processes with results which we expected. In the first place, the markets for our goods has enormously expanded and canned goods are now an everyday necessity in every home. Secondly, the number of people employed in making the tin cans has increased greatly and, I may add, not only in this country but throughout the world.

"The process has led to an unsatisfied demand for more skilled people and indeed the problem of finding and training skilled staff is one of our greatest concerns. That is why we have at this moment over 400 apprentices, to say nothing of men in training for professional and managerial posts.

"Automation, so far as we are concerned, has not only provided more work, but also more highly skilled work, which is correspondingly more satisfying to the individual and more remunerative to him. It may be that where automation has to be introduced on a large scale, some dislocation is inevitable, but I am sure that it will be short-lived.

"I am absolutely convinced that automation is something which should be welcomed by the working people of this country, not only in their capacity as producers, but also in their capacity as consumers. It is far too often forgotten that the people who make the goods are the people who buy or use them. It is in their interest to press for every known mechanical aid to production."

That extract from his 1956 review contains some very pertinent observations, worthy of thought.

Paul Einzig reaches this conclusion: "Automation is bound to proceed sooner or later whether we like it or not. Our choice does not rest between automation and full employment, but between prompt automation with the possibility of moderate temporary unemployment, and delayed automation with the certainty of grave perennial unemployment, until our progress has caught up with that of our competitors."

One can, perhaps, understand the thinking which leads to feather-bedding and restrictive practices. One can only hope that the cost of these is realised, before it is too late, to be far greater in national damage than the possible cost in terms of personal hardship of temporary redundancy which, in any case, does not seem to have been experienced so far.

Material

No one seems to know, or have any real idea, of what the cost in terms of material may be.

One can argue that there is a possibility of shortages, bottlenecks, and even more rapid exhaustion of some materials. The rate of consumption of some materials is very rapid, and there are some shortages. Steel is an obvious example of a shortage.

There are alarmist reports of a general lowering of water-tables, and a world shortage. In the South of England the water-table is said to have been lowered during and since the War by many feet, but the blame is, in some quarters, placed upon the U.S. forces and not industry. Water is a vital commodity in many industries.

Should there be Government determination of priorities before it is too late? Should there be exploration for and extraction of hitherto remote supplies and who should pay for it? One can pose many similar questions. The only real fact seems to be that no one knows the answers. Dare one hope that somewhere the right people are thinking about them and trying to determine the answers?

Doubtless the research into new materials will grow rapidly and show results. Textiles are an obvious example where new synthetic fibres seem to be announced every day. But are the basics from which these fibres come showing signs of early exhaustion?

The writer has been unable to find much of an authoritative nature on this aspect of the subject. It clearly is of extreme importance and extreme difficulty. It demands continual research, and it would seem essential that the problem should be tackled at Governmental level.

Power

The projected rate of industrial growth will demand an accelerated supply of power, particularly electricity. There are fears that in the mid-1960's there will be serious shortages because supply will not keep up with the increasing pace of demand.

It seems clear that coal must be supplemented very rapidly, and new sources of power obtained. What should they be? Must it be a series of Calder Halls, and what are the cost effects likely to be?

Power consumption should be more effective, because less wastefully used, as a result of automation, but the savings are quite unlikely to provide other than a fraction of the increased general demand.

The cost picture of new sources of power does not seem very clear. Can it be proved whether power from Battersea is cheaper than Calder Hall or Loch Aber or *vice versa* ? Does it matter ? We must have it and, therefore, the only vital question is: "Where can we get it?"

Is the position such that, for many years, almost any source of supply is worth it, no matter what the cost?

Some unfortunate cost controller is going to have the sums to do one day, and his answers may well lead to the adoption of one or another methods quite decisively, but it is doubted whether anyone really knows right now. If that is true, there may be some costly mistakes. Perhaps, though, they might not be quite such mistakes because they might have saved some disastrous situation at the time.

Who can say that the Brabazon adventure was a mistake, costly though it undoubtedly was in money terms?

Industrial pattern

There is a distinct tendency to imagine that the advent of automation will mean a concentration of industry in fewer and fewer giants, and that the small man is doomed.

Is automation to be confined to the production of a few standardised articles in very large quantities?

If this happened the cost to the community would be the loss of the strengths of small men to a country, and they have many strengths and advantages, and the loss of variety. There is, of course, far too much needless variety very often, but at least let us have some.

The evidence of the stimulation to the growth of the giants is, however, not very convincing.

A small highly-automated plant can concentrate on long runs of a few products, providing a most useful service to a large-scale assembler. Many of the large-scale concerns are surrounded by a host of small men, each producing one or two components. There seems no reason why this industrial pattern should not continue to expand.

Another result that may be seen is a change in the location of some industry. There will be somewhat less need to site a new plant in the midst of a closely populated area, because of the fewer number of people required in any one automatic plant.

It is also not at all essential that an automated plant must, of necessity, have very long runs. Set-up for a change can be much quicker than a similar change in a factory not so highly mechanised, and any one automatic plant can handle comfortably quite a few products.

It seems very likely, therefore, that automation will see a growth in the number of small specialist firms, and that those firms will by no means be confined to one or two products.

There will always be some people prepared to pay for something different and if there is some degree of standardisation, there might even be a growth, or regrowth, of small specialist manufacturers on a craft basis, catering for the amount of craft trade at present existing, and for some of the variety at present handled by larger concerns who will cease to make more than a very limited variety.

That there will be some standardisation and simplification is, probably, inevitable.

Disappearing costs

The cost accountant is going to find his ideas changed quite considerably. Apart from a change of thought, discussed in the next section, some of his old familiar friends in the expense world look like vanishing or at least becoming a great deal smaller. Their place will be taken to a considerable extent by the increases in technicians, planners and so on.

The sort of expense that will tend to vanish is much of that embraced under the general head of Work Study. Time Study men, Motion Study, piecework, fancy forms of incentive, these will have little place in an automatic plant. The calculations will be done in an office and on a drawing board.

Operator efficiencies will cease to have much meaning, and the old distinction between direct and indirect labour becomes dead.

Operators will cease to take part in the production itself. They become more of a supervisory nature, but the stimulus towards interest and enjoyment should be great. Many men will enjoy controlling a superb piece of automatic machinery far more than operating a capstan lathe and, despite the idea of making things automatic, there have to be some controllers, until the completely automatic factory becomes common.

Some expenses such as maintenance will probably increase. The amount of maintenance will increase in volume in that the new types of plant will require it and the quality and therefore cost of maintenance staffs will go up.

There is likely to be a decrease in the cost of jigs and fixtures, but there might be an increase in the cost of tools.

Scrap and rectification should tend to be reduced because of the higher degree of control possible with automatic rather than human means, particularly where highly-developed feed-back systems are in use.

The cost of such things as setting-up will alter drastically.

By and large, the cost accountant will have to start again and think of what amounts to a new schedule of expenditure.

In the trades where package-filling to set weights is necessary, for example, there should be a much more accurate control on such weighings, with reduced

losses due to over-filling or claims from customers for short weight.

Cost accounting

Cost accountants will be faced with re-thinking their approach. Some of the expenses which are likely to disappear or change have been mentioned in the previous section, but the problem is a wider one basically.

In the past many schemes of control accounting have been built around statistics of operator efficiency, waiting time, etc., and the behaviour and cost of people generally.

This approach, while doubtless absolutely correct at the time, will have little or no meaning under automation.

Operators will have no effect on speeds of production, because the speed of the equipment will be set and controlled by the engineering department. The only real effect an operator could have would be to fail to see that the equipment was fed with raw material where this was not also automatic, and to fail to deal with breakdowns promptly.

The stopped-time will become one of the important points to watch and will be one of the factors which the cost accountant will highlight.

The incidence of maintenance becomes important, and the whole question of overhead allocation will require careful thought. There will be a need for much more accurate and detailed study and allocation. Sloppy methods adopted because they were good enough will not do any more. They never really did, but many thought they did.

Fractions of pennies will count much more when considering this or that line of action.

As mentioned earlier, the accountant will be drawn into top level management in a more positive way. Things like operation research, now receiving increasing interest, will demand closer co-operation from him, as much of the basic information must come from the cost office.

What should be avoided by the cost accountant is an approach conditioned by any preconceived notions. No one is very clear what is going to emerge as important and what is not.

Managements will be bombarding the cost departments with demands for all sorts of new information and the cost accountant must be broad-minded and alert enough to respond, and think out fresh approaches.

Much of the management accounting approach today is concerned with the behaviour of people. As suggested, this concern is becoming of secondary importance and the accountant must become concerned primarily with the behaviour of automatic machinery.

Not so much appears to have been published so far on comparative costs, but the following figures have been fairly recently published and show some indication of the fairly drastic shift of emphasis.

The Austin Motor Co. have given the figures shown in the adjoining column.

The Ford Motor Co. have shown for a 7-multi-station transfer machine doing motor car cylinder blocks:

30 operators — One-half of non-transfer line on tractor blocks

31½ min. cycle time — 71 minutes for tractor line

Cost approximately halved.

Service to small concerns

The increased costs of mechanising, planning, controlling, standardising and simplifying, to mention a few of the possible sources of increases, will be frightening to many small concerns. To some they will be prohibitive. To some they will be quite uneconomic, because there will not be enough work to keep the highly-qualified, highly-paid staff fully employed.

Is there a possibility of developing design and planning service on a hire-basis for small people? There seems to be a clear field for this type of central service in computer work, where programming and machine time will be on hire. Why not in some of the other fields?

Perhaps the larger customers may find it worth their while to provide such services to some of their smaller but vital suppliers. It has been suggested that assistance towards the cost of equipment may well be provided by large customers to small men, and the idea of providing skilled technical help also would not seem to be too difficult or far-fetched.

To some extent work of this kind is already done, much technical help being given by the larger concerns, and also by consultants. But this is not organised as a rule in quite the way of regular but part-time service, whereby the part-timers are a permanent and necessary part of the management set-up in a smaller concern.

It is almost certain that some, at least, of the consultants have such a service very much in mind, if not as yet in actual being.

Conclusion

Perhaps one of the better results of the current interest in automation is that apart altogether from the mere fact of doing things much faster, more cheaply and more efficiently, the things being done

(*concluded on page* 447)

	13-*Station Transfer Machine*	*Individual Machines*
Capital cost ...	£25,903	£30,850
Floor space ...	390 sq. ft.	500 sq. ft.
Cost per m/c operating hour ... (Power, Depreciation, Insurance, Repairs, floor space, etc.)	£3. 13s. 3d.	£4. 8s. 9d.
Labour cost per hour	11d.	£2. 17s. 2d.
Output	3,000 Components	2,500 Components

COMPUTER-ASSISTED PRODUCTION CONTROL

by W. J. KEASE

Mr. Kease is with A.E.C. Ltd., Southall, Middlesex. He was educated at the Temple Technical School and the Merchant Venturers' Technical College, Bristol. His early practical training was obtained in the Motor Works of the Bristol Tramways and Carriage Company, Limited, where he was subsequently employed in the production and development departments.

In 1950, *he joined a well-known firm of consultants as a Design Engineer, being promoted to site Engineer-in-charge in* 1952.

In 1953 *Mr. Kease joined A.E.C. Limited, as Technical Assistant to the Production Control Manager, assuming his present post as Technical Assistant (Director's Office) in* 1955.

PART I: THE BACKGROUND

THIS PAPER will be devoted to the consideration of the production control department in a company manufacturing heavy road vehicles, and especially with the introduction of an electronic computing machine into its routine procedures of co-ordinating and regulating the company's output.

The function of production control in an industrial concern is one of attempting to effect a compromise between two things which have all the *prima facie* appearances of being irreconcilable opposites. It has to endeavour to satisfy every requirement of the sales market, and every need of the production factory; to give, in effect, maximum service, and yet, equally, to get maximum productivity. To obtain the best practicable settlement between these factors, two things are implied:

1. The best possible forecast of the earliest possible product deliveries compatible with the minimal risk of disappointing the fewest possible potential customers.
2. The attainment of the maximal level of plant utilisation consistent with the smallest possible variation from the cheapest available processing methods.

Production control is not, therefore, an *outcome* but a *device*: a device which, at a determined level, will initiate certain actions, subsequently appraise them for divergence and ultimately indicate such corrective action as may be necessary. As a device it depends for its adequacy upon communication, for, as Professor Wiener has pointed out, *control* is merely communication that has been made effective. For the communication to *be* effective, then obviously its information content must be high, the interference level " low" and the communication channels well-defined. The state of interdependence obtaining in any system depends directly upon the speed with which a significant event at one place is adequately transmitted to every other place and it will only operate properly if, when its communications are directed into these fixed channels, the transmission of their contents is at a sufficiently fast rate from one point to the next to enable the system to operate as a whole. A production control procedure must be designed so that the activities of each of its portions conforms with its total activities. If this mutual agreement does not exist,

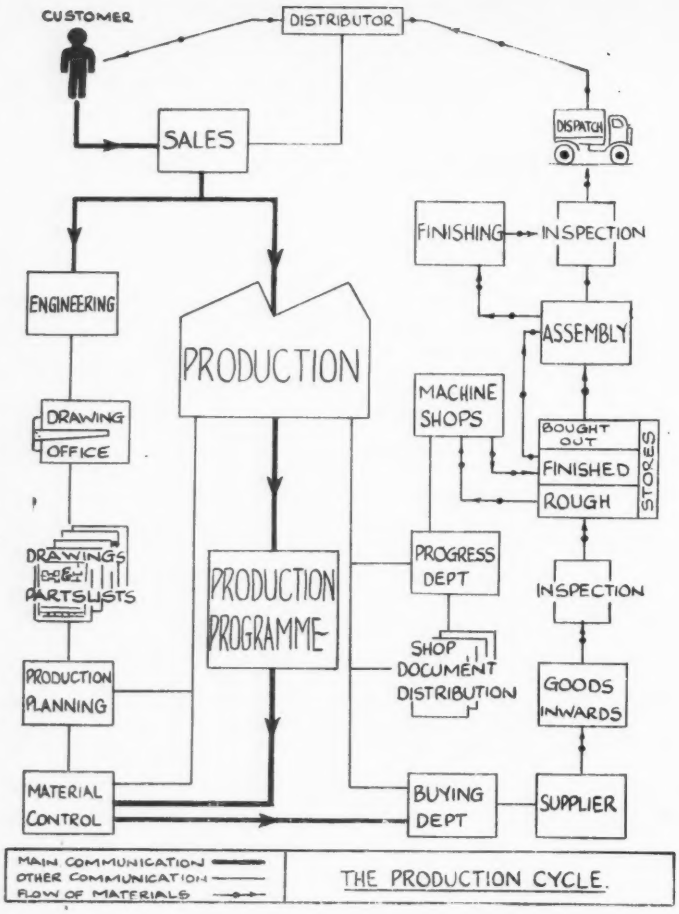


Fig. 1. The production cycle.

then the end result is not orderly and meaningful, but a jumble of semi-independent processes and the " department " exists only in the imagination of a biased observer; in real terms it is a collection of entirely separate units and processes.

Consequently, if a production control procedure is to function effectively, it must have access to vast quantities of continuous data and the ability within its own mechanisms to transmute those data into the form which, when expressed as physical action, is suited to the needs of both the customer and the manufacturer. These overall requirements may be considered as being channelled to form two main activities: the development, by mathematical methods, of a comprehensive production plan; and the translation of this plan into the necessary action through the processing of control information.

Of these two the first is of the higher order, for it should be a direct interpretation of the Board's production policy which should, in turn, be very largely based on objective attempts to determine the volume and types of sales which can be expected within pre-established date limits. The extent of the second cannot be too rigidly generalised upon, for each industry has its own highly individual control structure and, in any case, the precise scope and authority of the production control department itself varies from one individual concern to another (Fig. 1).

Production control in the heavy vehicle industry

In the British heavy vehicle industry generally, production control is a mixture of the serialised and order varieties. There are very few of our manufacturers who construct over 40 twelve-ton vehicles, or their equivalent, per week and fewer still who make over 60, and these levels of output hardly lend themselves to wholly serial processing methods, particularly if the range of products is wide. As a consequence, there is a certain amount of batch machining flow at established rates founded on long-term production plans, but at the same time a proportion of the work is undertaken to satisfy the needs of individual short-term orders, each of which requires an exclusive

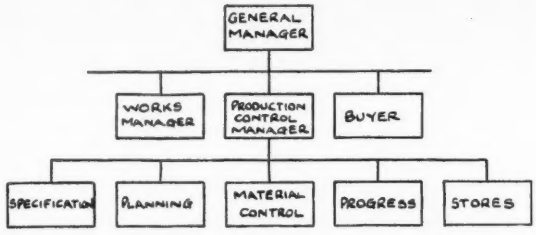


Fig. 2. The Production Control Department of the Manufacturing Unit

plan. All major assembly operations tend to be on the continuous line principle, so there is a perpetual need for the reconciliation, *via* the stock inventory optimisation, of the two methods.

The production control department in a specific company

The production control department in the Company on whose practice this Paper is based, forms one-third of the manufacturing unit, as shown in Fig. 2. It is responsible for liaison with the sales organisation—which is established as a separate company—and, in conjunction with that body,with the formulation of production programmes based on the already mentioned determination of probable sales. It is responsible for receiving and analysing information issuing from the drawing offices; the requisitioning, scheduling, receipt, storage and issuing of all materials; the compilation of machine tool loading statistics based on the production programmes and the implementation and continuous recording of achievement through the medium of its progress section.

The first move in the manufacturing procedure is the issuing by the sales company, to the manufacturing company, of a bulk order covering definite quantities of basic vehicle types which it is anticipated will be required during a stated period commencing not less than nine months from the date of the bulk order. The bulk order is, in effect, a long-range sales forecast, which, when received by the production control department, is analysed into part number form and the total quantity needed of each part is calculated. Then, taking into account any over-commitments for material made against existing sales orders, requisitions are issued to the purchasing department, who place orders with suppliers.

Later, a production programme is issued (compiled jointly by the sales and manufacturing companies) listing in weekly form the order in which the vehicles covered by the bulk order are to be built. The vehicles on the production programme represent definite *orders*, so it is now possible to calculate the rate at which the material is needed from the suppliers; it is also possible to take into account material for any special features which customers require to be incorporated.

A document called a traders' schedule is issued instructing suppliers when to deliver and in what quantities. As the material arrives it is booked in, and, when it has passed inspection, the outstanding balance is reduced.

This procedure may appear straightforward, but it must be appreciated that it has to be carried out for every part number on vehicles contained in 24 main groups, comprising a possible (though not probable) 270 vehicle types and 30,000 different pieces. Account has to be taken of such things as a part number being used in varying quantities on different models and the necessity, on occasion, to procure the same material from more than one supplier.

Every transaction (ranging from a simple " goods received " entry to the complex assessment of a traders' schedule) involves one or more calculations followed by some kind of entry on records. The total amount of clerical work involved is obviously very substantial.

The work of compiling the machine tool loading summary is comparable to the foregoing. It involves treating each factory-machined part separately, assessing its total requirements in the form of different machining operations: milling, drilling, grinding, and so on, in accordance with the production programme. Account is taken of the economic machining batch sizes and the batch throughput times, and a document known as the factory schedule is created, showing the operation starting dates for each batch of each part number over the appropriate period ahead.

The plant capacity is naturally taken into account on the factory schedule, any possible overload being either sub-contracted or re-scheduled to an under-loaded period.

A master record card is kept of all material movements, goods received, rough stores issued, finished stores issued, goods dispatched, and so on, all of which involves large numbers of minor calculations and other office routines.

The data-processing procedure in conjunction with the foregoing state was an exclusively manual one and had functioned in a satisfactory manner for a number of years. The growing signs were, however, that the system was becoming increasingly insensitive to the various conditions imposed on it, and it was decided to review the requirements for the operation of a production control procedure and to determine what measures were needed to transform the conclusions arrived at into an effective control technique. At this stage it was obviously not known what conclusions would be reached, nor whether the " technique " would involve anything more elaborate than the doubling of the clerical staff.

Initial investigation

Whilst some of the important, and self-evident, steps were to investigate the volume and quality of the paper-work throughput and the matrix on which it operated, it was equally apparent that a vital requirement was to ascertain to what extent the purely

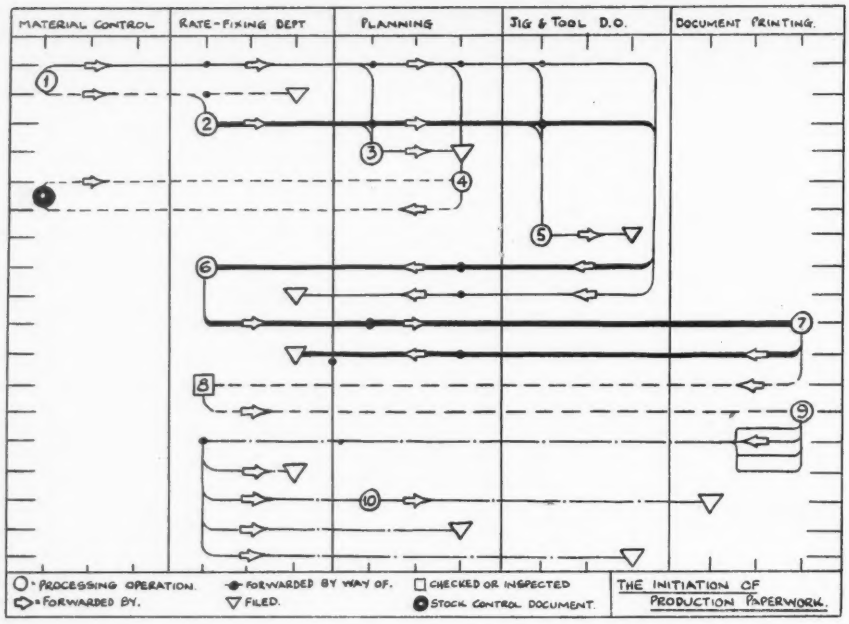


Fig. 3.

Flow Chart following an investigation :

(1) Material Control issue a " production release ", together with a drawing of the component approved for production.

(2) Ratefixing Department compile a temporary process layout and pass this with the " production release " to the Planning Section, the drawing being filed.

(3) Planning calculate economic batch size and produce temporary planning study, acting on the "production release ".

(4) The throughput data are recorded by Planning on the master Material Control card.

(5) The " production release " is sent to the Jig and Tool D.O. together with the process. Jig and Tool record what tooling is available and file details of the component for future action. The "production release " and process layout are returned to Ratefixers via Planning.

(6) Ratefixers adjust temporary layout to suit available tooling, and forward layout to Document Printing Section via Planning. The " production release " is filed.

(7) Document Printing produce plates and forward proof copy to Ratefixers.

(8) Ratefixers check proof and pass back to Document Printing with authority to initiate production paperwork.

(9) Document Printing produce paperwork and forward complete set to Ratefixers, who file Master Process, send tooling record to Jig and Tool D.O for filing, and planning study to Planning for filing.

(10) Throughput card is finalised by Planning and sent to Document Printing for use as reference when batches of parts are scheduled on manufacturing departments.

quantitative aspects of the product had changed over the twenty or so years the system had been in operation. In other words, to discover if the nature of the product had changed to a degree that the mathematical and control methods inherent in the system were inadequate.

This was done and although, naturally, the company worked on the basis of manufacturing the maximum number of products from the minimum number of pieces, the demands of competition in expanding world markets had been high. While the rate of production had increased by an amount which may be called "X", the number of different piece parts making up the range of vehicles had increased by 20X, the number of units such as gearboxes and axles had increased by 10X, and the number of vehicles in range by 13X. In addition to this, the customer pattern had changed to the extent that the number of individual customers had outstripped by several times the increased rate of production.

These factors were, in themselves, sufficient to suggest that the insensitivity of the system was possibly caused by its increasing inability to deal with an ever-growing load at a purely data-processing level, and a subsequent investigation of the throughput confirmed this diagnosis.

The second investigation was carried out in two sections, and these have already been mentioned:—

1. The matrix on which the system's documentation circulated.
2. The volume and quality of the documentation itself.

It was soon discovered in relation to (1), that nobody knew exactly what the matrix was, though on paper a logical version of its layout existed which, if taken at face value, would have proved that nothing at all was wrong with this aspect of the production control procedure. The truth was that over the years the communication channels forming the matrix had become, for practical purposes, somewhat ill-defined, with the result that some people were getting documents they neither needed nor used, while others were not getting certain paperwork vital to the efficient functioning of their parts of the procedure.

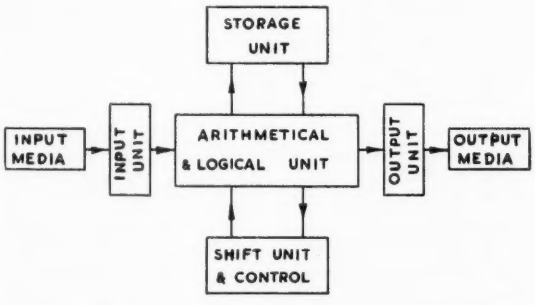


Fig. 4. An outline of an electronic digital computer

In relation to (2) the volume of the documents circulated was very great and the quality varied considerably (Fig. 3).

Any procedure involving people is, in any case, dynamic and subject to continuous change. One person may unilaterally decide that a particular portion of a routine is unnecessary and will ignore it. Another may decide that additional activities are, for what appear to be valid reasons, essential, and neither views the system as a whole. In consequence, over a long period of time, the real procedure drifts from the apparent and intended by a considerable amount. Such a drift, implying a lower quality of functioning, is obviously a brake on the progress made towards the achievement of the desired end.

The second investigation showed that the data-processing procedure operated on the principle of the " vicious circle." The slowness of the throughput, brought about by the increasing quantities of paper being circulated, was having the effect of lessening the accuracy of the master records, and important decisions were being made on a basis of false data. The inaccuracy of the records—constant " checking-up " being essential—was slowing the operating speed still further. Manufacturing schedules were compiled on information containing all manner of generalisations necessitated by the lack of adequate data-processing tools and time, and valuable " action " time was being lost.

Whilst it was realised from the outset that, in spite of all ambition to the contrary, it is impossible to manufacture a complex product without a correspondingly complex analytical and control device, it was also realised that the overall system being controlled must be the best that can be devised. Thus, arising out of the first investigation, two recommendations were made which have no direct bearing on the subject of production control as being dealt with in this Paper. These were: a systematic reduction in the variety of models to give maximum reduction in the variety of individual piece parts, and the inauguration of a marshalling scheme to give maximum information with regard to the direct availability of materials and an increased efficiency of materials flow.

Initial analysis leading to proposals

The production control procedure, it will be recalled, is being considered as concerned with two main activities:

1. The development by mathematical methods of a comprehensive production plan.
2. The translation of this plan into the necessary action through the processing of control information.

It is apparent that both these activities depend on a foundation of the four fundamental tenets of arithmetic, together with such special data-input, data-processing and data-output measures as the individual organisation demands.

Office arithmetic is trivial and boring, but voluminous and time-consuming. It consists, for the most part, of one or two additions or subtractions

per operation, though there are occasionally multiplication sequences involved, and, very occasionally, division.

The results of the second investigation suggested that an important requirement, and possibly an easy one, was to speed up the arithmetic. Some form of machine seemed indicated, it being well known that the simplest arithmetical routine to mechanise is addition. Subtraction and multiplication follow; division is the most difficult of the four. It was also deduced that merely to extend the manual method in other, non-arithmetical directions, even if the system were extensively revamped for the purpose, was not to provide the answer, since it appeared that the rapid inter-relation of separate pieces of information and data feed-back necessary for accuracy and greater control could not be achieved by the use of more and more clerks.

The possibilities of the increasingly publicised electronic data processing equipment were now, for the first time, considered, information being gathered from all representative sources.

Digital computing machines

An electronic data-processing system is built around a central computing machine and, since most business data processing is concerned with "numbers" or "digits," the machine is usually termed a "digital" computer. In simple terms, an electronic digital computer is a device which performs calculations and certain other logical operations through the media of electrical transmissions and discharges, in accordance with a numerical scheme based on digits which progressively do not vary. It is normally designed so that an entire sequence of operations is performed on the machine itself, there being no human intervention from the time the data are entered into the machine until the final results are produced. It is also capable of performing any given sequence of operations a fixed number of times on different sets of data. This cycle is known as "iteration", and the device which causes the correct sequence of operations to occur at the correct time is known as the "control unit." The sections of the machine which operate on the digits in the performance of addition, subtraction, multiplication and other routines are known as the "arithmetic unit."

Because the machine, using the speed of the electron for calculating purposes, can operate at so fast a rate that a human operator cannot possibly supply it with data at a comparable speed nor write down the answers as fast as the machine can calculate them, special measures have to be taken to provide the machine with "input" and "output" devices. As yet computers cannot read human handwriting nor generally recognise formalised script, so the input devices have to be fed with media coded in a manner the computer can assimilate. In a like manner, if output media have to be retained for further machine processing, they have to be suitably coded by the output devices. If the output is required for further processing by manual methods it has to be conventional, which pre-supposes that it must be presented in an appropriate form—often on specially printed

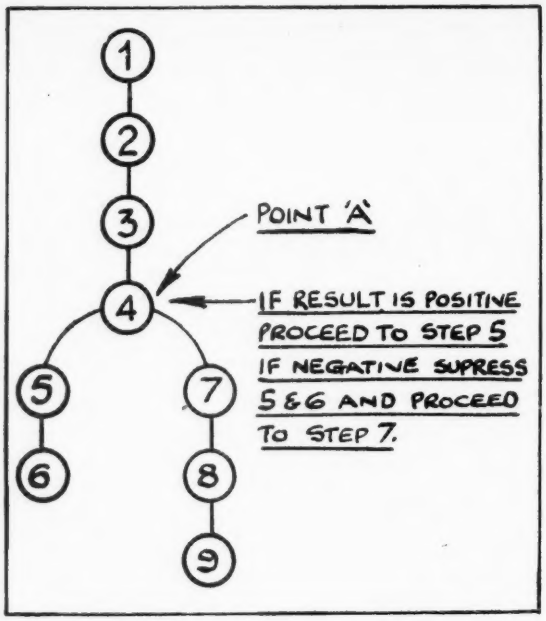
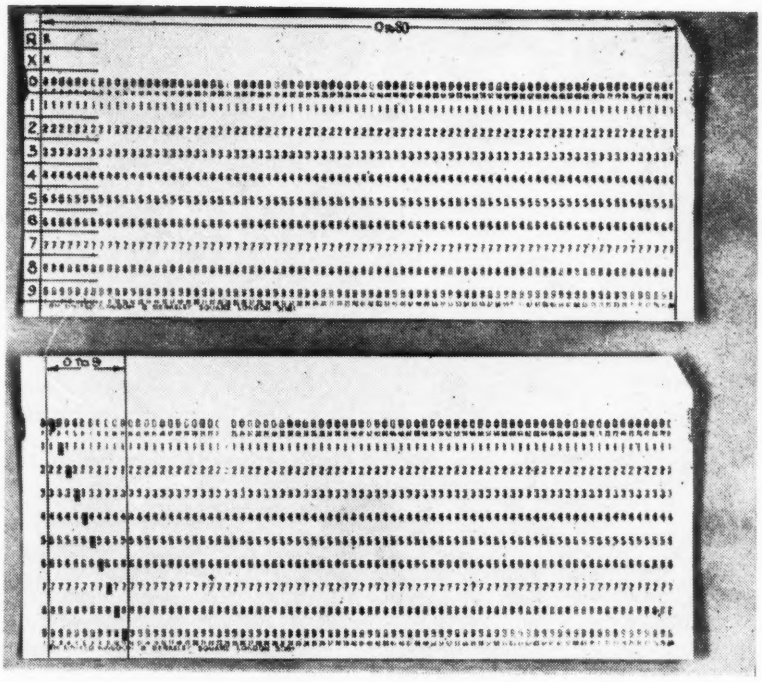


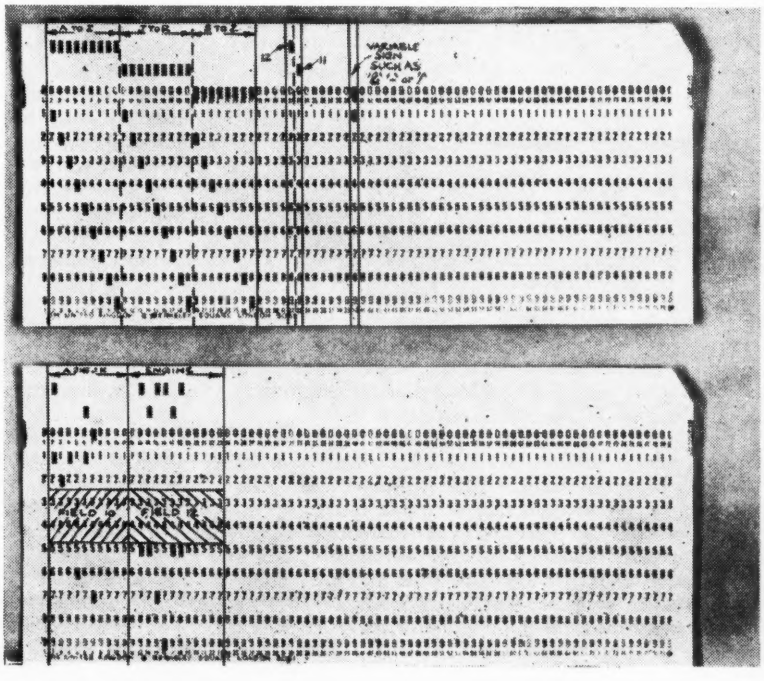
Fig. 5. An illustration of "branching"

stationery—ready for use. In addition to the mathematical content, such output must often contain alphabetical digits to classify it by title, trade name, and so on, under one or several headings (Fig. 4).

Digital computers have, in addition to the ability to perform a fixed cycle of operations a given number of times on different sets of input data, a feature which is unique, and which will be of increasing value as they are applied more and more to the resolving of commercial problems. This feature relates to the ability of the machines to vary certain portions of the cycle of operations according to the results obtained in immediately preceding portions, and is called "branching" or "transfer." This is shown graphically in Fig. 5, an indication being given that the quantitative nature of the result obtained up to point "A" automatically directs the machine to one of two courses of subsequent action. The whole set of operations necessary to solve any specific type of problem is called the "programme," and the total list of different and separate operations a particular machine is able to perform is called the "order code."

The section of the machine used to hold intermediate results of calculations and other factors is called the "storage unit." A digital computing machine designed for commercial use is, for economic reasons, usually provided with storage only sufficiently large enough to contain all the factors for use in calculations and to accumulate results for output under different headings, the storage being cleared after each separate and discrete series of operations. Since, and as has already been indicated, a commercial routine (such as production control) must have access to vast quantities of continuous data, it





Figs. 6 *(above)* **and 7** *(below)*.
Specimens of punched cards

follows that the main storage is provided by means of some external medium.

External storage — punched cards

There are many types of external storage media, but one of the most economical and convenient forms is the punched card. By means of a code of holes these cards allow a flexible method of recording information and permit relevant data to be initially processed, selected and fed to the computing machine in a very efficient manner. Punched cards may also be used as move tickets and other engineering shop documents, etc., permitting large-scale economies in stationery to be made, and time saved in translating from ordinary language to computer " language."

Recommendation for production control

In connection with the production control procedure under review, it was determined that electronic data processing equipment with punched card actuation might be a practical proposition and it was resolved that the machinery should:

1. be capable of dealing with a very large volume input of alphabetical and numerical material;
2. be able to store data required during calculations and hold them for immediate access;
3. perform most normal arithmetical operations during the standard time of one card passage but, in the case of more elaborate calculations, delay output until the work was completed;
4. accumulate the results of calculations until required;
5. have the facility of dual output, i.e., punched cards or printed tabulations and be able to output at speed in both alphabetical and numerical symbols;
6. be capable of programming in a simple, effective manner;
7. be reliable, adaptable, and economical to purchase (or hire), and operate.

Consultation with specialists

The next step was to hold preliminary consultations with the principal manufacturers of punched-card actuated electronic data-processing equipment, and reports of appropriate installations in America were studied. In addition, a visit was made to a Continental firm using data-processing machines to control a batch production factory. Although this latter company manufactured sewing machines, the variety of their products and the number of pieces involved showed what could be achieved with the latest electronic office equipment.

After this preliminary work, a computer manufacturer was invited to make an exhaustive survey of the Company's needs. This survey affirmed the variation of product and the piece part and material content of each; the material procurement and processing cycles; the stock control and plant loading measures dictated by the sales market and the factory capacity; the load and flow of documents at various stages; and full details of those factors bearing on the processing of data for control.

A comprehensive report, with recommendations as to the machines required, was submitted to management and a series of round table conferences took place. After final deliberations at director level, a contract was signed to hire a series of machines—centred round an electronic unit—which answered the seven requirements outlined.

PART II: THE NEW PROCEDURE

The coded input

The punched cards measure $7\frac{1}{4}'' \times 3\frac{3}{8}''$ and an unpunched general specimen is shown in the upper half of Fig. 6. In all cases the information is carried in the form of rectangular punched holes in the body of the card, which has its vertical dimension divided into twelve and designated from top to bottom R.X.O.1.2.3.4.5.6.7.8.9, and its horizontal into eighty columns (each capable of containing one digit) numbered from left to right, 1 to 80. The digits 0 to 9 inclusive are shown punched in columns 2 to 11 in the lower card in Fig. 6.

Alphabetical characters are represented by two punched holes in each column, A to I being denoted as R1 to R9, J to R as X1 to X9, and S to Z as 02 to 09.

This arrangement is shown punched in columns 2 to 27 inclusive in the upper card in Fig. 7. The combination 01 may be used to represent a sign such as "-". "/" or " & " and is shown in column 40; " R " can also mean 12 or 11d, and " X " mean 11 or 10d, as shown in columns 32 and 33.

Since cards are used as general purpose documents it is usual to have selected information which is already punched into the card, printed in normal characters along the top edge. A card bearing the part number A216JX and the title " Engine " is shown in the lower card in Fig. 7. Each significant group of digits, such as a part number or a title, appears in a group of adjacent columns known as a card " field "; thus in Fig. 7, A216JX appears in a part number field of ten digits maximum capacity, and the word " Engine " in a field of twelve digits capacity. Field lengths are completely flexible and are designed to suit each particular application.

Libraries and files

Cards are contained in what have come to be termed " libraries," " status files " and " history files." Libraries contain fundamental information relating to the manufacture of the product, and may only be altered for either or both of two main reasons:

Change in product design.

Change in manufacturing method.

In the present case, three libraries were established:

1. Model library—containing details of all the units (axles, gearboxes, etc.) used on each model.
2. Unit library—containing details of all the subassemblies and piece parts used in each unit.
3. Piece part library—containing details of the material used to make, and all the operations performed on, each piece part.

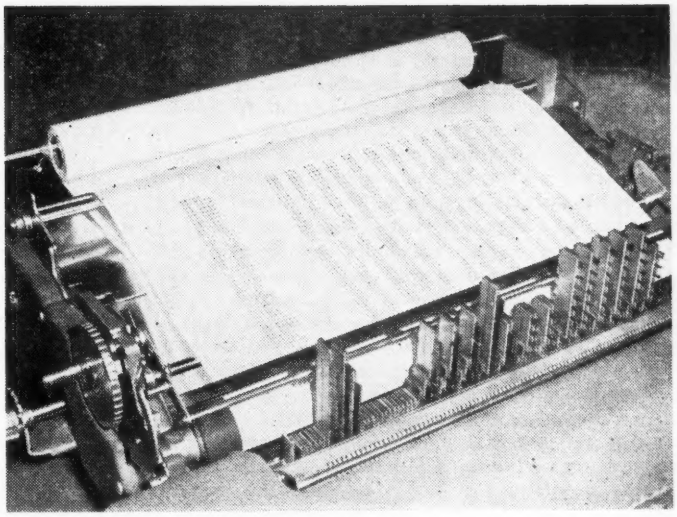


Fig. 8. A production schedule being printed direct from calculations

Status files containing current positions of each item of stock were set up under the following headings:

Rough material stock file—giving " in stock " and " on order " quantities, " allocated " and " unallocated " stock data.

Finished material stock file—giving " in stock " and " in process of manufacture " quantities, " allocated " and " unallocated " stock data.

Bought-out finished material stock file—giving comparable information to that contained in the rough material file.

A further status file contains details of available plant capacity.

History files contain all retrospective information relating to transactions affecting the status files, and history files such as " orders on suppliers," " goods received " and " spares orders " are being established.

To date, the basic libraries are complete, a bulk order has been analysed, stock recording is in operation, and two sections of stock control. Machine tool loading is in a fairly early experimental stage. The brief outline of the data-processing technique which follows, is not, therefore, *fully* backed by practical experience. So far as is known, the installation will be the first of its kind in the country to be performing a full routine on production control and while it will be of experimental nature for a period, a working procedure has been devised.

The processing technique (Fig. 8)

The new electronic data processing procedure begins with the analysis of a bulk order from the sales company. The relevant model cards are withdrawn from the library with all the appropriate unit cards behind them. They are put through the computing machine preceded by instruction cards stating " 200 sets of units form Model 'A', 250 sets for Model ' B,' 200 sets for Model ' C ' " and so on, according to the requirements of the bulk order.

The computer calculates the number of each unit required for each model and punches cards (one for each unit) with this information. The unit cards are then sorted into alphabetical and numerical order.

This procedure is repeated with the sub-assembly cards preceded by the unit cards, the computer calculating the total quantities required of each sub-assembly, and punching blank cards with these data. Once again the process is repeated, now with the piece part cards preceded by the sub-assembly cards, the computer calculating the piece part requirements and punching the answers into blank cards. The piece part requirements cards are sorted into part number order.

The finished stock status cards are merged with the requirements cards and fed into the computing machine, which deducts unallocated stock balances and produces a requirements card for each " finished " part.

The material cards from the piece parts library are then merged in, so that rough-material part numbers and sizes can be established. The stock of rough-material cards are merged in, the machine deducting any unallocated stock balances. Through its output printing unit, it prints a list in part number order of material to be purchased. This list is used by the purchasing department as its authority to purchase.

When the orders are placed, the purchasing department returns to the data-processing section information on the names of suppliers and quantities placed on order, punched card input bearing this information being prepared.

At a later date when the production programme has been arranged, the computer calculates the rate at which the material is to be delivered; due procurement and processing time having been allowed.

A traders' delivery schedule is printed on the output unit of the computer, and simultaneously punched cards bearing this information are produced. A copy of the printed schedule is sent to each supplier concerned.

A somewhat similar procedure to the foregoing applies to the carrying out of the planning function; the computer calculates the starting and finishing dates for each operation performed on each batch of work, and by totalling, the overall machine load. Should a particular section of the factory be overloaded, the jobs suitable for sub-contracting are automatically selected—a check having been carried out to ensure that the jobs so affected could not be re-scheduled to an underloaded period.

When the computer calculates the delivery dates for material, it punches up goods-received cards, which are set aside in a special file to be issued to the goods-received department a week before the material is due in. Should the material, when delivered, vary from the pre-punched information, the cards are easily adjusted.

In a similar manner, when the computer calculates starting dates for batches of work, it pre-punches material requisitions and job operation cards. These latter are intended to act as the core of progress effort.

Five days before jobs are due to be commenced, a printed list is supplied to each foreman showing the work to be performed on the particular section for which he is responsible. Job cards, bearing the starting and finishing dates, are also issued at this juncture. As jobs are completed the operation cards are returned to the data-processing section and checked against manufacturing schedule, all jobs behind schedule being listed daily for manufacturing priority action.

There are, of course, many other jobs laid out for the computing machine in addition to the principal ones just outlined. There is the maintenance of the stock status files, for example. Stock movement cards are regularly sorted into part number order and merged with current status cards; the computer performs the required balancing calculations and automatically produces new stock status cards.

The computer is also programmed to calculate, three weeks before erection is due to begin, quantities of parts to be issued against the vehicle erection programme, and to print a list of " shortages," if any, for progress action to be taken.

To sum up: the whole routine analytical and clerical procedure of the production control department has been designed to be swift, accurate, and to high-light " action " points. It has been designed to be as automatic as possible and to release the clerical staff in the department to more essential work.

Part III: The Computer and its Ancillaries

The electronic data-processing section comprises fifteen machines, three of which, when linked together, form the computer. This group, which has been colloquially termed " the hook-up," is an amalgamation of a fairly flexible plug-board programmed calculator with punched card input and output and an accounting machine which acts as a card reader, output printer and addition storage device.

With the smaller computer, say, one which is capable of performing up to 100 programme steps, a very useful way of controlling the sequencing of operations is by means of plug-board control panels. With this method, the circuitry of the machine is physically changed for each separate set of steps (representing a complete " programme ") the computer is required to perform.

By means of a formalised arrangement of connections, wires to complete specific circuits—and hence to allow desired operations to occur at the correct time—are always plugged to the same places on the plug-boards.

Since the amount of work required to prepare a programme plug-board is considerable, the boards themselves are usually made detachable—as shown in Fig. 9—and for each " standard " job plug-boards are maintained in fully wired-up conditions. By this method the computer, which is designed as a general purpose machine, becomes "special purpose" as soon as a particular set of plug-boards is inserted.

The computer is shown in the photograph Fig. 10. The main arithmetic and storage unit is on the left, the punched card input, printed output and subsidiary storage unit is in the centre and a punched card input and output unit is on the right.

A simplified layout diagram of the machine is shown in Fig. 11. As will be seen, it consists of read

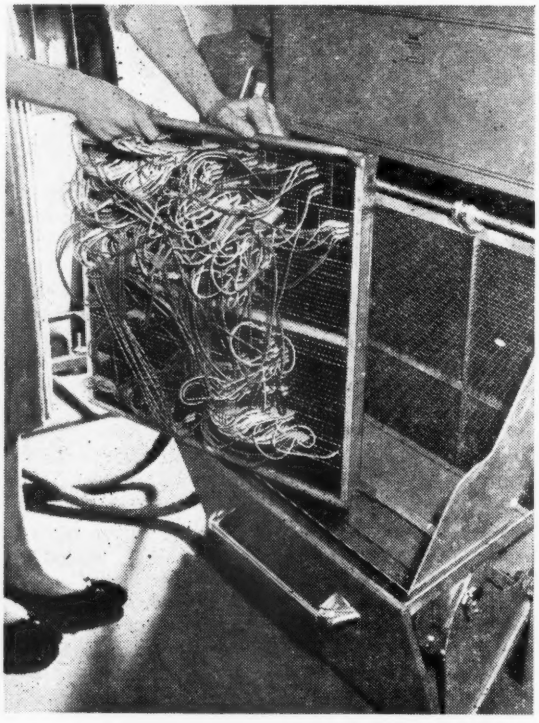


Fig. 9. A pre-wired plugboard entering the machine

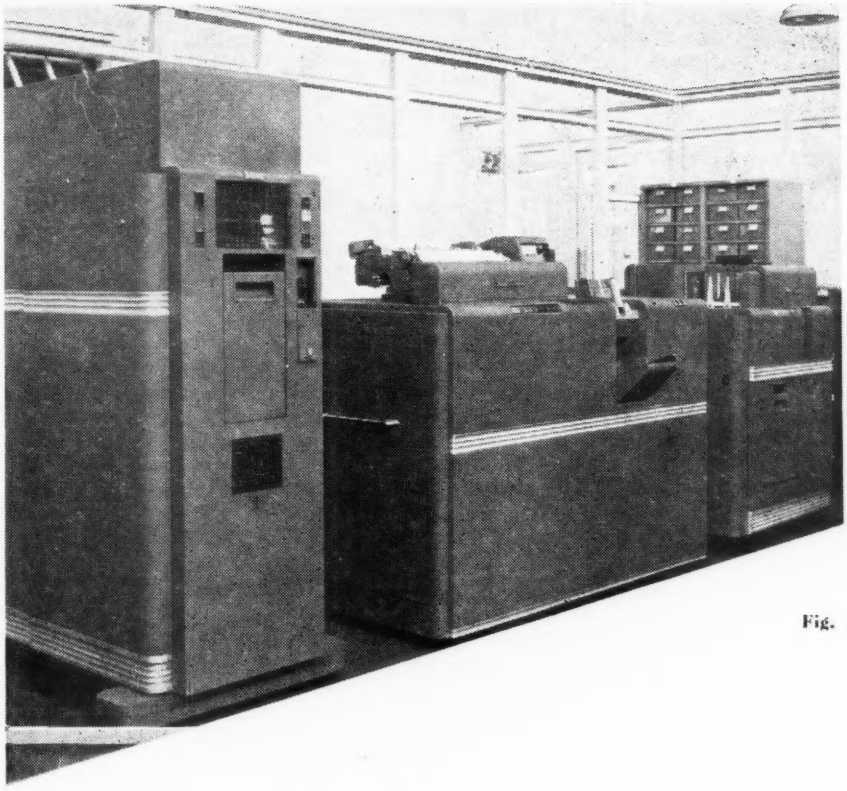


Fig. 10. The computing machine

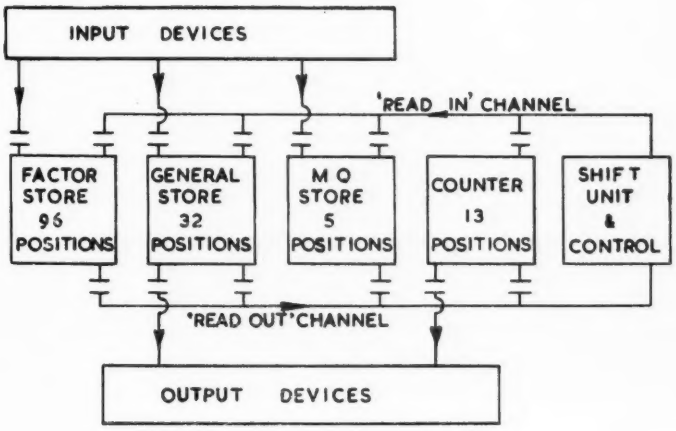


Fig. 11.
Schematic layout of calculator

in and read out facilities, storage devices and an arithmetic unit as already mentioned, together with a control unit. The main storage consists of two basic types—electronic decimal counters and electric relay. The electronic storage counters are made up of four binary " flip-flop " valves on the 1.2.4.8. basis. There are 32 positions of general storage of this type, a special 5-position storage for storing the multiplier when multiplying and in which the quotient is generated when dividing, and a 13-position counter or accumulator in which all arithmetic occurs. This counter has the facility for handling decimal carry-overs The wire relay storage consists of 96 positions, again on the 1.2.4.8. basis.

Reading in is by way of an 8-wire bus circuit, as is reading out. To read in a digit, a series of pulses equal to the value of the digit are applied to a counter. To read out, a series of ten pulses are applied, a pulse being transmitted through the appropriate " read out " bus wire when the counter arrives at zero; the counter, of course returning to its original state after the application of the tenth pulse in the applied series.

The " column-shift " unit, Fig. 12, and the " add-subtract " control regulate arithmetical operations the performance of which involves the transferring of digits from one storage unit to another. The column shift unit, as will be appreciated from the diagram, is a switching network for shifting connections between the reading in and reading out bus wires under the control external signals.

To demonstrate the workings of the machine in a simple mode, the diagram in Fig. 13 shows the plug board wiring for the arithmetical operation,

$$x(a - b) = y.$$

It has already been stated that one of the fundamental advantages of computing machines is with respect to " branching " or conditional transfer. On the present machine, the achievement of this result involves the suppression of certain individual programme steps or groups of steps, and the repetition of certain groups of steps as a process of iteration. All these things can be " plugged", and the machine can in one iteration perform 70 programme steps.

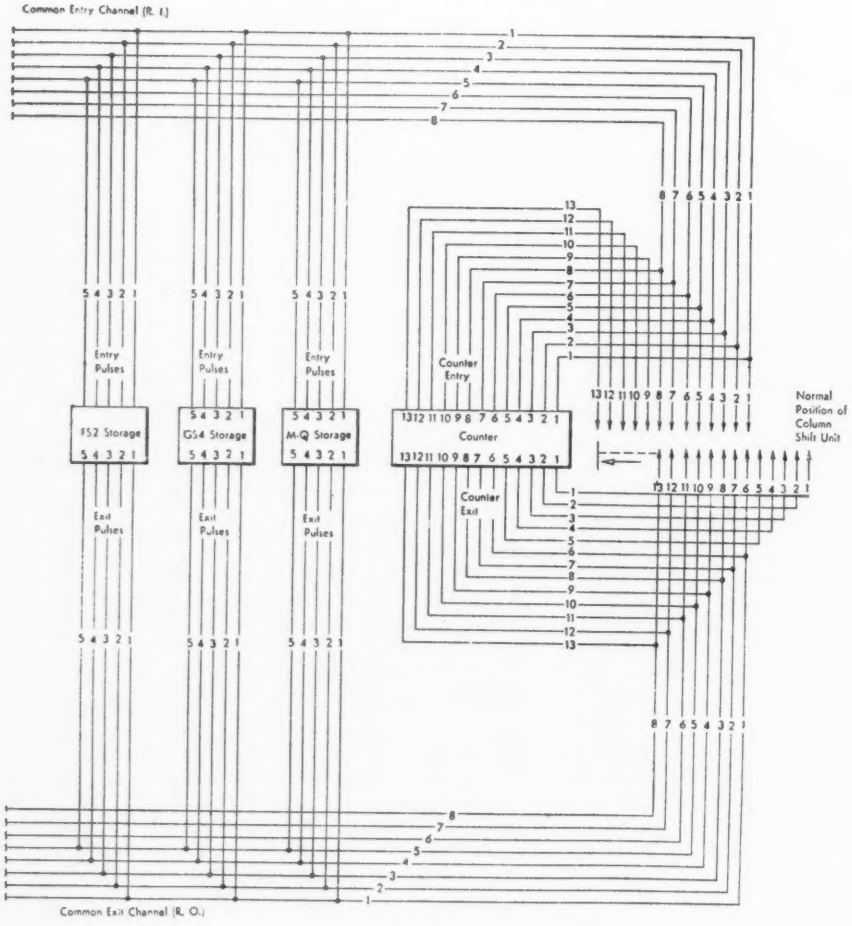


Fig. 12.
Column-shift network

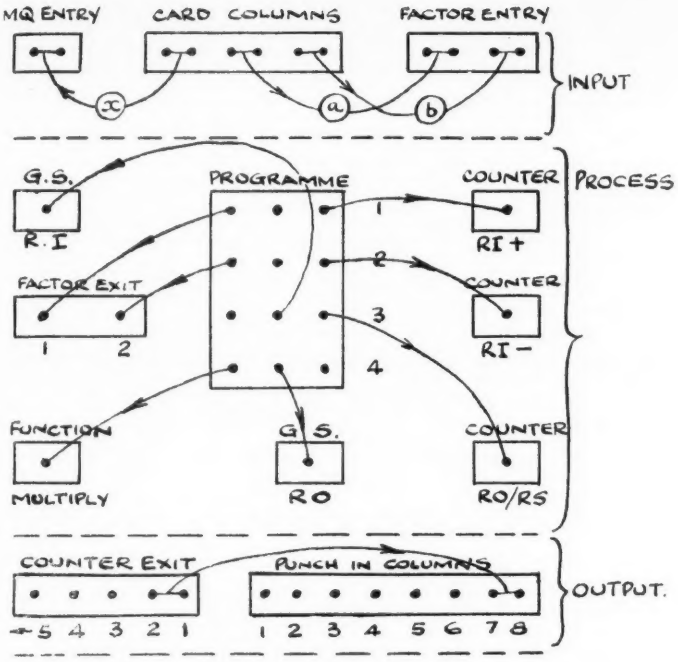


Fig. 13.

The plugboard above demonstrates the wiring for the simple equation x (a-b) = y.

Input The factors x, a, b, are each contained in two columns on a punched card and when read by the computer, a and b are read into factor storage and x into multiplier storage.

Process On programme step 1, factor 'a' is read out of storage and into the counter. On step 2, factor 'b' is read out of storage and subtracted into the counter which now contains (a-b). On step 3, the counter is read out and reset, (a-b) being read into storage. On programme step 4, this storage is read out 'x' times into the counter, which at the end of the step will obviously contain x (a-b).

Output The counter exit channels are wired to the punching control channels, so that as the counter reads out on programme step 3, the answer 'y' is automatically punched into the desired columns of the same card as that containing the original factors x, a, and b.

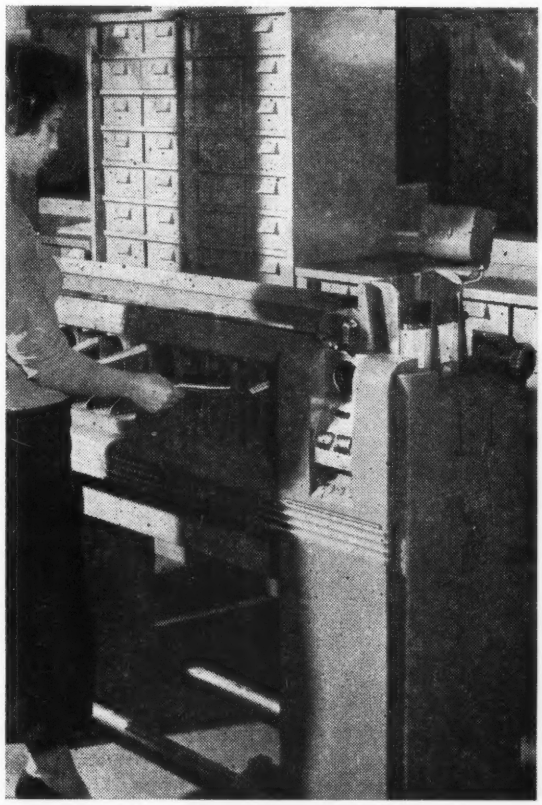


Fig. 14 *(below)*. A sorting machine

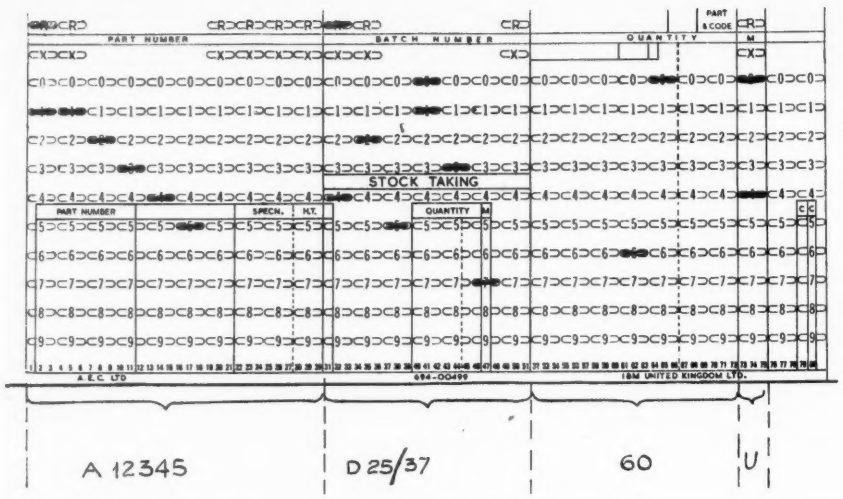


Fig. 15.
A mark-sensing card

The accounting machine portion of the " hook-up " has the facility to enter factors into storage in the arithmetic unit, as well as to store up to 80 digits within its own electro-mechanical unit. The machine as a whole can read all 80 columns of a card and punch all 80 columns of a blank card.

The speed of the machine is $\frac{1}{2}$ millisecond for addition, 11 milliseconds for multiplication, 13 milliseconds for division and 48 milliseconds for transfer.

The other twelve machines in the data-processing section comprise three card punches, three card verifiers, two sorters, one collator, one interpreter and two reproducers.

A card punching machine is operated electrically from a keyboard similar to that of a typewriter, alphabetical or numerical information being punched by a single key depression. The machine can be set up for duplicating repetitive information at the rate of ten columns per second.

The verifying machine is similar to the punching machine, but instead of punching, it electrically senses, at each key depression, the information which should already be punched in the appropriate column. If an error is detected and confirmed, i.e., if the information in the column being sensed is different from that transmitted by the key being depressed, the machine locks and the card has to be removed for repunching.

A sorting machine is shown in Fig. 14. It allows punched cards to be repeatedly arranged and rearranged in different combinations, permitting a great many analyses to be prepared from one original recording in the cards. The machine incorporates an electronic amplifying unit and sorts at a rate of 39,000 card columns per hour.

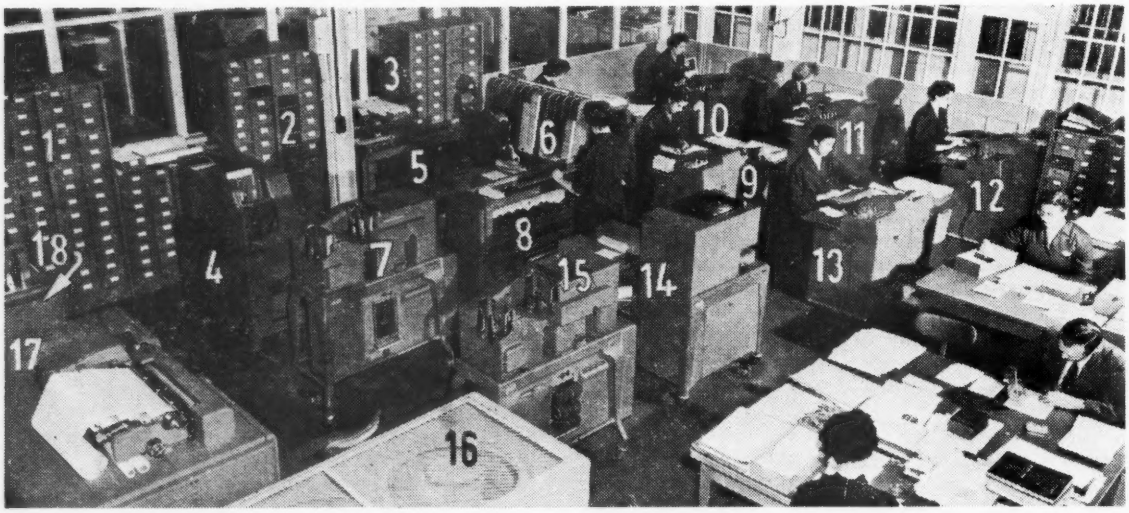


Fig. 16. The electronic data processing department, showing : 1 - 3, files and libraries ; 4, collator ; 5, sorter ; 6, sorting rack ; 7, reproducer ; 8, sorter ; 9, verifier ; 10 - 12, punching machines ; 13, verifier ; 14, interpreter ; 15, reproducer ; 16, calculating and storage unit ; 17, card reader and output printer ; 18, punch card input and output machine.

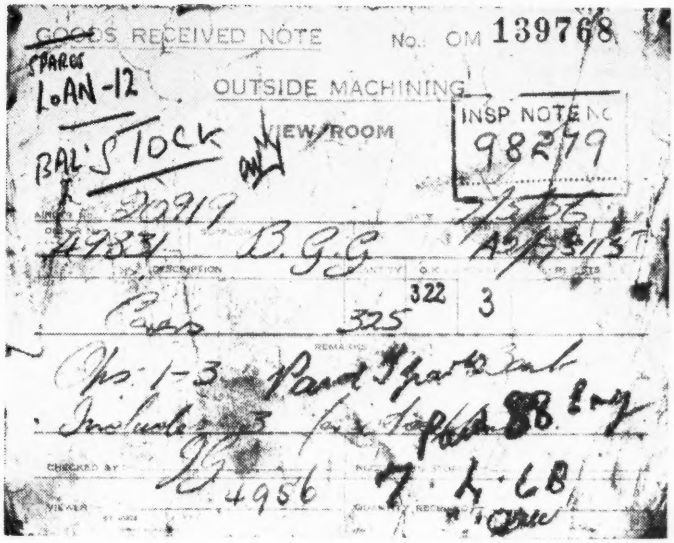
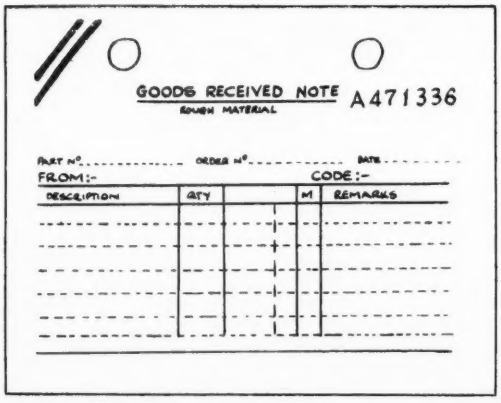


Fig. 17. An " unrationalised " document

DOCUMENT LAYOUT.



Information from transaction documents is reproduced on IBM cards in accordance with a precise method. This is to say that the Part No. always appears in the same place on the punched card, as does every other item of information concerned in the transaction. The reason for this rigidity in lay-out is that the computing machine can only deal with information produced in a uniform manner.

To assist in the translation of information from transaction documents to the cards, it is important that the transaction documents be filled in clearly and accurately. The Part No. must always appear in the place reserved for Part No., the Order No. must always appear in the place reserved for Order No., and so on. Documents must only be used for one transaction, i.e. pass forward notes must only record the passing forward of material into stores, they must not be used for the subsequent issuing of material, as has been the practice in certain instances in the past.

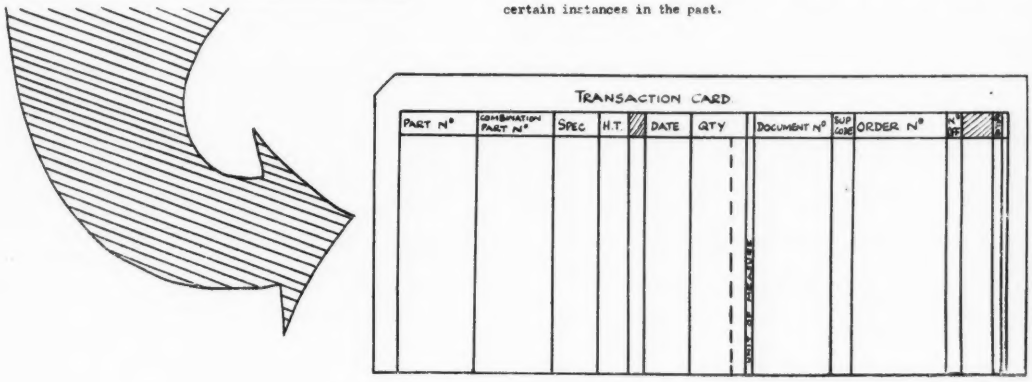


Fig. 18. An instruction sheet

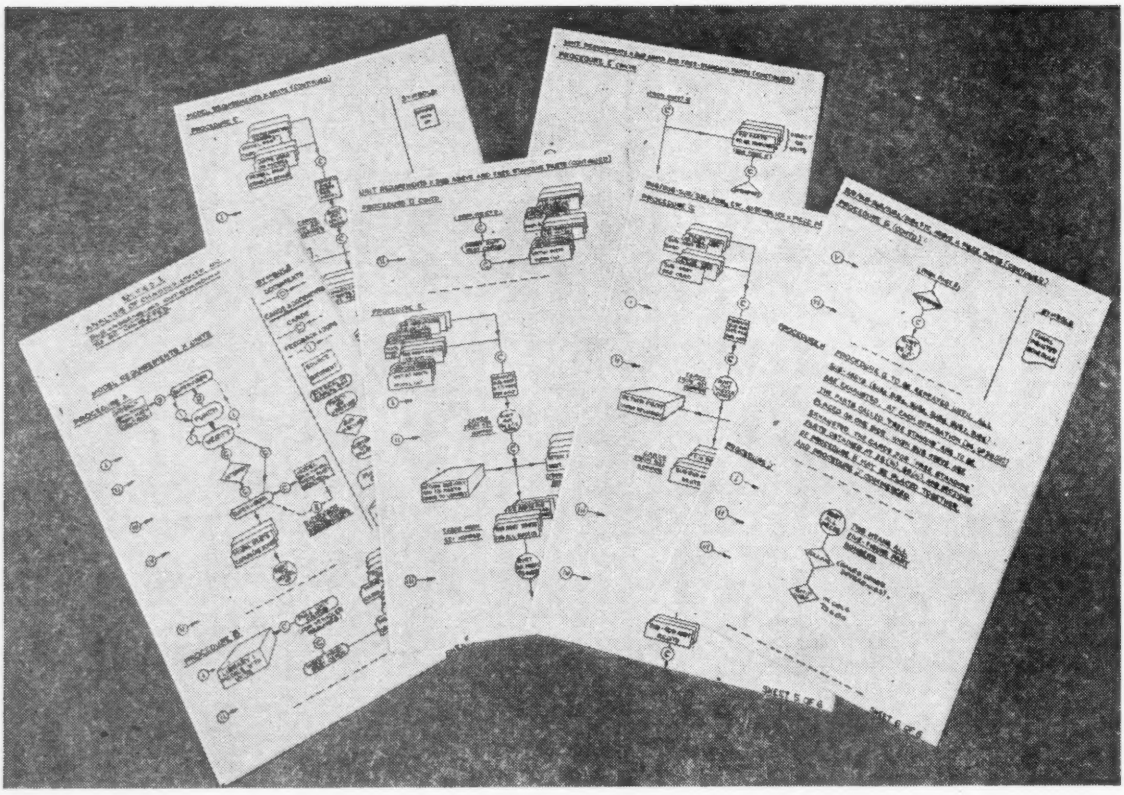


Fig. 19. Flow charts for a section of a typical analytical operation

The collating machine automatically performs such operations as: filing current cards with previous cards; replacing old cards with new cards superseding them; selecting all cards earlier than a certain date, as for analyses of jobs behind schedule; combining gross requirements cards with stock status cards; and separating them again after their use in computing machine operations.

The interpreting machine translates the holes punched in the cards by printing on the faces of the cards the alphabetical and numerical information which the holes represent. The machine speed is 3,600 cards per hour.

A reproducer will repetitively copy information from a master card into any number of detail cards and into any required position in those cards. It will copy information contained in one pack of cards into another pack, both packs remaining separate and in order.

One of the two reproducing machines is fitted with what is known as a "mark-sensing" device. In certain applications, such as the issuing of material from a store, it may not be possible to use pre-punched cards; equally, to punch new cards from hand-written chits may be laborious. So special cards are used and quantities involved are marked in pencil on the faces of the cards, Fig. 15. The reproducer transmits an electrical charge through the graphite on the marked surface and automatically punches the information into the same cards at a rate of 6,000 cards per hour (Fig. 16).

PART IV: INTRODUCING THE NEW PROCEDURE

General comments

The preparation for the introduction of the procedure and the introduction itself is being spread over three full years, of which two have already passed. This may, possibly, seem rather a long time, but no portion of the procedure has been transferred to the machines without considerable preliminary preparation as the following examples will show:—

1. The whole of the parts lists from which the libraries were compiled were not only checked against drawings but also reconciled with actual practice, and, where practice proved different from the written data but more suited to the needs of production, the data were changed.

2. The whole of the data circulation matrix was checked, and, where necessary, modified. The designs of the existing documents were carefully scrutinised and adjustments, in the light of changed circumstances, were made.

In numerous instances, the document designs were discovered to be quite satisfactory, but the method of presenting the information on them was not. A typical sample of one of these documents is shown in Fig. 17. It will be seen to bear three separate and distinct transactions, and no control system, manual or machine, can consistently remain accurate if its information is presented in this fashion.

Sheets such as that shown in Fig. 18 were circulated.

3. In the case of the machine tool loading project, a small self-contained factory was used as a testing ground; the new procedure being introduced in three separate stages. To begin with, a physical check was made of all work in process of manufacture, the existing shop documentation was withdrawn and punched cards—one for each individual operation outstanding on each batch of work—issued in its stead. As operations were completed, the appropriate cards were returned to the data processing section and automatically compared with the production schedule, any deviations being notified to the progress section. The particular advantage of this stage was that useful " know-how " regarding the circulation of punched cards through the manufacturing departments was obtained.

The next stage was to compute electronically the already manually calculated batch schedule and to make such adjustments as were required.

The third stage was to analyse a proposed production programme—to follow the stage two schedule—working backwards from the desired completion dates, due action being taken with respect to local over-and-under loaded conditions of the plant (Fig. 19).

Selection and training of staff

There do not appear to be, as yet, any fully acceptable " rules " for the selection of suitable staff for the operation of the types of machines being discussed. Certainly, however, one of the most important qualities needed is " mental discipline," and if this is

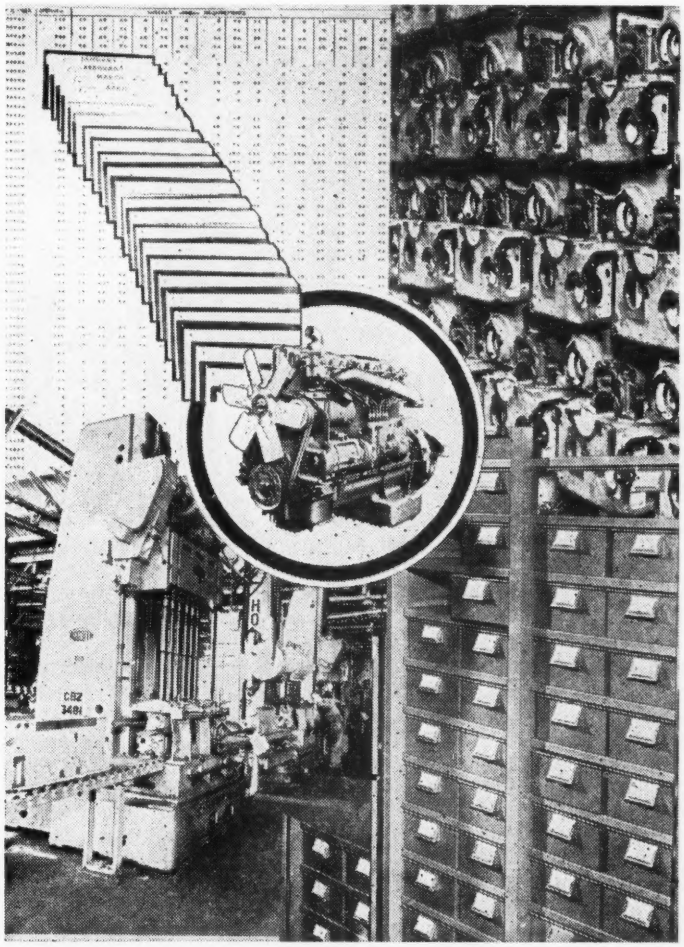


Fig. 20.
" Montage " used for instruction purposes

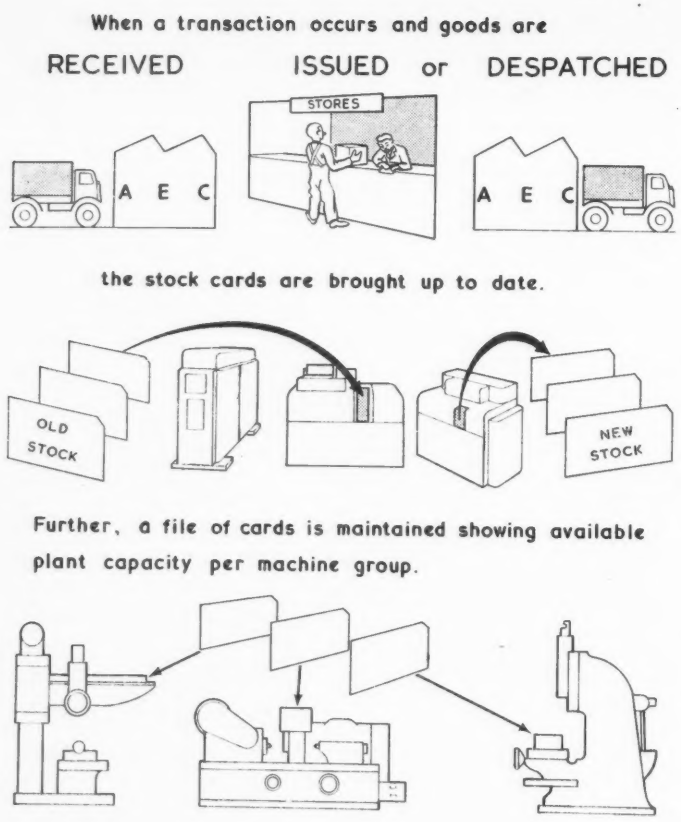

When a transaction occurs and goods are
RECEIVED
ISSUED or DESPATCHED
STORES
A E C
A E C
the stock cards are brought up to date.
OLD STOCK
NEW STOCK
Further, a file of cards is maintained showing available plant capacity per machine group.

Fig. 21. Page from explanatory booklet

absent, training is wasted. With the right mental approach, however, employees will leave nothing to chance; they will appreciate that they are using machines which are essentially logical in operation and that any information presented to the machines must be in a precise and established form. Both operators and machines must combine to form a data-processing unit.

A simple example of this discipline is shown by the punching and verifying operations. The verifying machine checks the accuracy of the cards which have been punched by the punching machine. Since the verifying machine operator works from information used by the punching operator, the chances of both operators making the same mistake is extremely small. However, in the early stages of using the system such errors were being made. It was found that when the verifying machine detached an incorrectly-punched card, the operator withdrew the card from the machine, looked at the information punched on it, then operated her machine accordingly. By not having the right mental approach, this operator had doubted her own ability and preferred to believe that the punching machine operator had been correct.

These errors were soon discovered and the punching and verifying machines were " isolated " from each other and no two girls worked together as a team. In addition, every card issued has to be accounted for and all errors passed to the supervisor.

Most of the initial training on all machines is provided by the manufacturers of the equipment as part of their comprehensive service, which includes full maintenance of the machines and advice on programming.

Punch and verifier operators were selected in accordance with a simple aptitude test and trained on the customer Company's premises.

Their basic training consisted of learning the machine keyboard fingering, and how to get the best performance out of the machine. These operators are exclusively young girls of 16 to 20, drawn mainly from secondary modern schools. They translate routine documents into punched card form and, by a set method of testing, ensure that the machine produces cards which are suitable for subsequent processing.

Training for the sorters, interpreters and reproducers was provided in the form of a one-week school on the premises of the supplier. This included basic instruction on the operation of the machines, examples of plug-board programming, tests to see if the machines could misfunction, and standard routines to be performed at regular intervals. Tests for these machines consist, in the main, of putting test cards with all alphabetical characters and digits through the machines to ensure that all the holes are read correctly and at the proper speed.

The collating machine course lasted one week and was only taken by operators who successfully completed the first course.

Computer programmers and operators completed a three weeks' course on the hook-up after a week on the auxiliaries and a week on the collator. Programmers are expected to have mathematical abilities up to Higher School Certificate or National Certificate standards and, if possible, a bias towards electrical engineering, though this is not essential. Those who operate—as distinct from programme—the computer, need not have this mathematical ability to the same extent, but should have a higher level of mental discipline than the auxiliary machine operators, and an aptitude for assimilating information.

Successful completion of these courses does not mean, however, that operators are wholly capable of undertaking full responsibility for machine operation. This only comes after some months of regular work on the Company's products. In practice it was found that employees on the operational side with a knowledge of the Company's products could be trained effectively, but that as a rule the analysis of the problem and programming it into the machine could be done rather better by a person who did not have too detailed a knowledge of the Company's products, and had not become engrained with the way the manual system operated.

Consultation with staff representatives

The proposal for the electronic data processing system was introduced to all staff levels by short round-the-table discussions. These concerned the work to be performed on the machines and the general manner of operation of the machines. Illustrated booklets, which graphically depicted various salient points, were supported by actual demonstrations on the machines.

The first group to be contacted were the staff representative committee. When they were assured that the scheme posed no serious redundancy problems, they received it enthusiastically and requested additional information.

The second group consisted of trade union representatives and members of the joint production advisory committee. The latter group then disseminated the information on the shop floor (Fig. 20).

The third group were those employees concerned in the preparation of routine documents for translation into punched cards.

It has already been mentioned that a production control system, being dynamic and involving people, is liable to unregulated and unnecessary change. Such change has a potentially grave effect on the efficiency of the system as a whole, and so it was stressed to this group that all documents should be filled in in a precise manner and that any apparent anomalies should be notified to the supervisor. In this way considerable improvement was gained in production control records, even before the computer was used (Fig. 21).

In all cases the new electronic data-processing procedure is being introduced gradually. In numerous instances the old and new systems are run in parallel, and only when the machine method is demonstrably running without flaw is the manual superseded.

Future projects

Other projects to those outlined are, of course, being investigated:

(i) *Labour-loading and requirements.* Since machine tool loading and factory capacity have already been planned, it can be assumed that considerable benefit would be achieved by undertaking the complementary work of labour-loading. When the production programme is analysed into constituent operations and manufacturing batches, the labour available can be scheduled to indicate what labour, of what specific types, is needed over the appropriate period ahead. This would necessitate setting up a complete personnel file in punched card form. Such a file would contain a short history of each employee and note any special attributes of an employee.

(ii) *Production of shop routine documents.* The project for machine tool loading does not include routine production of such shop documents as manufacturing process lay-outs. In an organisation such as that described, these amount to many thousands in the course of a year's production. It will be remembered that the number of individual pieces in the range of vehicles is approximately 30,000. The average number of operations on these parts is around 10. Each manufacturing process lay-out contains information on manufacturing times, jigs, tools, fixtures needed for the processing of components on machine-tools, and detailed instructions as to what precise operations are to be performed.

These lay-outs are now produced by embossed plates, up to three plates being required for each lay-out operation. This information can be translated on to punched cards for production on the printing unit of the computing machine, and possibly considerable amounts of time and money could be saved between the embossed plate and the punched card methods.

From the foregoing it will be seen that in the company described, electronic data processing is still in its infancy. It is quite easy to imagine other processes which can be electronised. The important thing to bear in mind at all times has been that enthusiasm and foresight must be tempered by the intention to get each section working thoroughly on the computer before a further section is attempted.

The slogan has been " Accurate data for precise control."

Acknowledgments

The author wishes to thank the Directors of A.E.C. Ltd., and also IBM (United Kingdom) Ltd., for permission to make use of the material contained in this Paper.

DISCUSSION GROUP D1

WHAT NEW SKILLS WILL THE FUTURE DEMAND?

by C. B. GIBBS, B.Sc.

Mr. Gibbs was educated at Hawarden Grammar School and served an engineering apprenticeship at Brookhirst Switchgear Limited, Chester, until 1930, *when he joined the Royal Navy in the Ordnance Engineering Branch.*

He served in the Navy until 1948, *when he retired at his own request to join the Applied Psychology Unit of the Medical Research Council, which was at that time under the directorship of Professor Sir Frederic Bartlett, C.B.E., F.R.S., M.A.*

Mr. Gibbs studied subsequently at the Cambridge Technical College, Birkbeck College, London University, and privately for external B.Sc.(L.U.). He was appointed senior scientist within the Medical Research Council in April, 1957.

IN the Sir Alfred Herbert lecture to this Institution in 1955*, Dr. N. H. Mackworth dealt with scientific studies of the skills which will probably be important in the future. He stressed the great potential value of this work in designing machines, setting out the general working environment, and developing effective schemes of training.

The present terms of reference are to be as provocative as possible, rather than to enlarge or develop Mackworth's admirable and well-documented Paper. The aim is to stimulate discussion and, perhaps, some tardy and much needed applications of the objective experimental work on human behaviour. The Paper, therefore, deals in the main with actual case studies from the services and industry. These fully support his general thesis, however, that in practice, all too often human behaviour is the subject for guesswork or for quiet despair. Since provocation necessarily involves some departure from philosophical detachment, the Paper is to be regarded as an expression of my own experience and opinion.

In general, industry accepts the need for objective facts and specialised knowledge in dealing with two main factors in industry, the machines and the money. The men are more often dealt with by individual opinion, intuition or experience, and the methods serve if no better can be found. But the measuring techniques and experimental approach of the modern applied psychologist have often proved better, and undoubtedly they merit wider trial and further applications. Most of the current studies deal with the transmission of information through the human senses to the brain. They have led directly to the design of better industrial instruments and controls, and to overall systems for controlling machines. But information and its presentation is the main factor in all human relationships.

* Published in the "Institution of Production Engineers Journal", 1956, Vol. 35, No. 4, pages 214 - 240.

The usual connotation of skill suggests the manual dexterity of the craftsman, but more widely, it denotes ease and precision in the performance of any activity.

The term can scarcely be applied to the present practice of management/labour relations for example. The future will demand that such activities should more nearly justify the description of a skill. It is hoped, therefore, that discussion will point to the areas where independent facts are most urgently required, and where communication in its widest sense could be most usefully studied.

The Paper briefly describes the development of experimental studies of human behaviour, their present status and the main causes of their current neglect in industry.

The future use and practice of "Human Engineering" is then discussed. This field is mainly concerned with the study of the relationships between men and machines, or their working environment. "Social Engineering" is defined as the study of the relationships between social groups, and of the determinants of social behaviour. The urgent need for further studies in this field is emphasised.

I. The development and present status of behaviour studies

Objective studies of human behaviour are of comparatively recent origin, arising as a reaction against the endless and age-old disputations of the philosophers.

But the tendency to speculate, to rely on introspection and opinion rather than experimentally determined fact, is by no means confined to armchair philosophers or the ancients, particularly in the sphere of human behaviour.

An old philosophical controversy well illustrates the points. Aristotle was long regarded as the exclusive fount of Divinely-inspired wisdom in Natural Philosophy, and an obscure passage in one of his works referred to the number of teeth in a horse's mouth. Rival interpretations were possible, so controversy developed and continued until comparatively recent times, when an early experimentalist was moved to open a horse's mouth and actually count the teeth.

Progress since that point has not been entirely satisfactory and quite recently, I heard this old story in a new and libellous setting. The modern version is that the exchanges had actually taken place between two of our major Ministries. This is quite untrue, of course, but the story has sufficient point to command wide circulation and popular belief, at least amongst those best acquainted with the institutions in question.

II. Reasons for neglect of behaviour studies

We now have more respect for science and verified fact, but prejudice and tradition can still obscure those facts relating to human behaviour. There are some major reasons for this neglect and these should be discussed and clarified by a few examples, since there are no apparent or logical reasons why they should persist.

Lack of knowledge

The main reason for neglect is simply the current lack of knowledge of the extensive literature on measured human behaviour which is now available. This is not surprising, since a recent handbook of Experimental Psychology (by no means comprehensive) contained over a million words. The subject is difficult and the practical implications are not readily apparent to managers and engineers, who are rarely trained in the scientific study of man. The inevitable result is that even the old work is rarely known and still less frequently applied.

In a recent case in point, a new, complex and expensive machine was being designed, and it demanded rapid and skilful action at one part of the cycle of operations. In such cases it is best to make a simulator or mock-up of the task, and to make tests on this before settling on the final design. The firm readily accepted this method, but did not at first appreciate the great importance of making frequent and accurate measurements of the course of learning, or of the need to use a large number of representative operators for the tests. They finally agreed to the suggestions, however, and the experiments clearly showed the importance of such measures. Differences of over four to one were found between the ability of the various operators. On overage, the operators took five times longer to reach a high level of skill than the training period originally proposed. The original scheme of testing would not have given the proposed engineering solution the fair trial that the later one provided. Much time and expense were saved by making the simulator tests in advance of final design, since the tests pointed to important modifications and improvements of the original idea.

But such techniques are still apparently the exception rather than the rule in designing the workers' machines and skills.

Another recent case brought out the great importance of the transfer of skill. Two tasks may be related in such a way that learning the first can give good indirect practice on the second. This makes its subsequent learning easier and gives positive transfer of skill. But in other cases the learning of a first task may actively impede the learning of the second to give negative transfer. These factors proved to be very important in predesign studies of a complex machine where several engineering solutions were possible. These were all tried out on a simulator in advance of design. The men practised on each solution in turn for a uniform period of time. The firm's assumption was that equal training periods on each arrangement would produce equal skill and so permit fair comparisons. But the results were conflicting and the firm sought advice. It was clear, on examining the records, that both positive and negative transfer were affecting the results when men changed between the different arrangements. Equal times in

learning were not in fact producing equal levels of skill because of the order of presenting the tasks and the transfer effects. Again, the solution was to take frequent measures of the course of learning, and only to test the men on a particular arrangement when a definite learning plateau had been reached. By such measures the most effective arrangement was found.

These simple psychological measurements made a great difference to the final efficiency of the man/machine system. The best arrangement as found by experiment was over twice as good as others which might well have been adopted had their selection been left to chance.

Human learning and the transfer of skill are important now and will remain so in the future. They have been studied scientifically by experimental psychologists for over 70 years, and many of the main determinants have been thoroughly investigated and presented in mathematical form.

The skills of the future may well demand that some knowledge, of at least the earlier findings, should somehow percolate through to industry.

The neglect of effective training is by no means confined to machine operators. I recently lectured at a summer training school for engineering undergraduates, held in a large firm. The purpose of the lectures was to shorten the transition time between students leaving University and becoming effective and knowledgeable members of the firm. The period of relative ineffectiveness is usually estimated at about one year at present, but the idea behind the school was to reduce it to three months. Personal experience of several current training schemes would suggest that this is a modest target in many cases. It is heartening to note the growing appreciation of such facts in the Engineering Departments of some Universities, and in some major firms. But a very great deal remains to be done, before basic findings are widely used in industry.

Lack of specialised responsibility for skill

The neglect of operational studies in industry is sometimes due to the fact that no one man has specific responsibility for the overall function of machines, considered as the mechanical extensions of man. Some machines are designed by teams of engineering specialists each with a limited sphere of responsibility, and in such cases it is easy to overlook their overall function of serving Man.

The classic example is perhaps a fighter aircraft which was designed by the usual teams of specialists. The resulting product was a fine technical achievement, somewhat marred however, by the inability of pilots of normal stature to get into the cockpit.

This particular example is from the U.S.A. but similar cases are by no means unknown in British industry. A recent examination of a proposed design led to the comment which was previously quoted in Mackworth's Paper. No fault could be found with the engineering design as such, but candour compelled the observation that one difficulty did remain. This was to design and manufacture the entirely new kind of human being who would be required to operate the proposed machine. It was fortunate that the consultation was made in time and the proposed idea was discarded.

The essential difference between the two countries does not lie in current practice or malpractice. It is that the Americans are taking drastic steps to remedy such situations whereas we, unfortunately, are not. U.S. Navy contracts for all machines which include a human operator contain the clause that the design must be passed by a specialist in human engineering. One major aircraft firm in America employs 14 specialists full-time on these duties. I know of only one appointment of this kind in the whole of British industry. A similar disparity exists in training courses and the production of text-books of human engineering. The British worker in this field gains what meagre consolation he may from the reflection that this new branch of science originated here. But rather typically, I think, the applications and full exploitations of this originally British idea are left to other countries.

Habitual 'sets' in thinking

A further main cause of neglect is the blinding effects of habit and custom. This applies to experimental psychologists as to others, of course, but they are perhaps a little more aware of, and on guard against its effects. They are newcomers to industry and this can be a definite advantage, in this connection.

One example of its effects is found in the design and layout of typewriter keyboards. Studies were carried out to test new layouts. The general idea was to place the letters most frequently used under the strongest fingers and relegate others to the weaker.

The arrangement which is optimal depends upon the structure of the particular language in use, which must first be analysed to find the relative frequency of letters (varying of course between different languages).

The studies showed the large improvements which usually follow this kind of investigation.

But it is possibly more important that further enquiry was made to find why such an ineffective design had been adopted in the first case. The account given by one reputable source is that the typewriter was originally designed by an ex-compositor. He took over the arrangement of printers' blocks with which he was familiar. This layout dated back to the Middle Ages. The story goes that the arrangement, although ineffective for printing English, was excellent for printing Latin, and this had been its initial purpose!

The moral of the second part of the story is more important than any lingering suspicion that it is a little too good to be true. This is that a great many machines and skills are relatively ineffective for human use for no better reason than "things have always been done that way".

This truth is probably so obvious that further examples are unnecessary. But in universal experience, the nose is always in clear view, but is rarely seen without a conscious effort. Some things are too close, and have been there too long to be readily noticed. This applies in industry, as in human anatomy.

The designer/user aspect

A further reason for the neglect of the operator's skills is perhaps the most important, and is the most easily remedied without specialised knowledge.

The designers of machines do not usually have to use them for any extended period.

An example of the effects is seen in the wide difference in comfort, convenience and safety between a commercial lorry and a private car. The fact that car designers usually drive cars, while lorry designers do not habitually drive lorries, probably goes far to explain the difference.

Some trenchant observations on this general state of affairs are now almost folklore. In the Royal Navy, for example, a Naval architect is popularly defined as "a man who designs ships he doesn't have to live in".

It can scarcely be doubted that the designers of many domestic appliances, cooking stoves and the like, are blessed with remarkably tolerant wives. It is difficult to believe that they have ever used their own products.

Subjective factors

Human beings are sometimes used ineffectively for a variety of associated reasons for which it is difficult to find a generic term. The neglect may stem from the typical human reluctance to take outside advice, or to submit a problem to independent investigation if this involves the surrender of any vestige of authority. In the extreme cases, this tendency may terminate in the well known disease of "N.I.H." (Not Invented Here), by no means unknown in British industry. Some years ago, work was carried out on the direction indicators of cars. At that time the flashing light turning indicators were not legal here, and our semaphore arm type was not accepted in several other countries. It is clearly an economic advantage to produce standard cars, which can be exported without detailed modifications, to all countries. It therefore, seemed useful to make controlled comparisons of the different signals.

A long series of tests was carried out, using human reaction times, mistaken responses, relative visibility, and the time to learn the meaning of the signals as the experimental criteria.

The studies gave clearcut results on their relative merits, and it was possible to point to the main faults of each type and to suggest improvements.

There was, therefore, real hope that the issue of legalising flashing indicators would be decided on the basis of measured data rather than opinion.

The status of scientific behaviour studies at that time is well illustrated by the fact that amended regulations soon followed the report. But so far as was possible, they were directly opposed to its recommendations on every major point. The result is that good, bad and indifferent car signals of many different kinds now appear on our roads. The resulting increase in confusion and uncertainty is causing the public concern and outcry which could have been reliably foreseen from the early experiments. The British public is in the unenviable position of repeating them on a larger scale and with much greater danger to life and limb. Industry and civil authorities, like the armed services before them, are learning the lesson the hard way, that it pays to have measured data of human performance. But there can be no doubt that the scientific method will ultimately replace individual hunches and opinions in this field, as it already has in the physical sciences.

Restrictions of investigation

A final reason for the comparatively ineffective use of people and their skills is the taboos and restraints which limit certain lines of investigations, because of their highly emotional content.

The subject of human engineering which Mackworth and I have discussed, in the main, is comparatively innocuous. This is not the case when certain extensions of the methods and findings are suggested. These extensions would carry the work into the field of social engineering, which is concerned with the relations, and methods of communication between people, rather than between machines and people. It is widely alleged that such investigations would be harmful, because of the existing tensions within industry.

Some recent experiments on repetition-work machines will serve as an example. One group of test workers were given machines which had a counter indicator in clear view. They, therefore, had continuous and rapid information on the number of items they had produced. Another group was given no numerical information of this kind. No bonus or incentive payments were given to either group, the experimental variable was simply the giving or withholding of plain information. The group who had information, or knowledge of results, gave consistently higher output of the order of 25%, and this obtained when the groups were changed round to equate the factor of ability.

There is little doubt that the human engineering aspect of the work will be applied. But there is considerable doubt whether the findings will be readily extended to social engineering, although this could be far more important. The nature of possible applications will be clearer if the main effects of information are described, since information provides the main link between human and social engineering.

III. The nature of information and communication

So far as is known, all human learning and hence the vast majority of human behaviour depends entirely on information and the way it is presented. Learning is impossible without knowledge of results, since mere repetition by itself gives no improvement in a skill. Information which is delayed by even a few milli-seconds is demonstrably less effective than that given immediately. Punishment or reward, however they are given, may themselves act as emphasised information, or stress other information which is currently presented.

Punishment is usually less effective than reward, because although it defines the action to be avoided, it does not pinpoint the desired course of action, as does reward. Its effects are usually therefore to

increase the variability of behaviour, and they do not necessarily point it in the desired direction.

Such findings point to many applications in industry. They are important, for example, in the design of incentive schemes of payment. All too often such schemes are altogether too complicated and so relatively unintelligible to the worker, and the rewards too long delayed on the conduct which has earned them. The essential association between a given action and its reward cannot therefore be readily made. A similar reduction of effectiveness with time also obtains with punishment, of course, which is most effective if made immediately after the undesired conduct. An exponential relationship is found between punishment and time, as between time and reward.

It is not suggested, of course, that a pay clerk should station himself at each worker's elbow. But is seems very likely that far better use could be made of symbols which could serve as token rewards, and many schemes could probably be made more direct, meaningful and immediate in their effects.

Such proposals have however caused the liveliest alarm in some firms, mainly because it is supposed that the unions would object to impartial enquiries on the effects of payment or information. It is doubted whether such an attitude is necessarily characteristic of trade unionism as such. One large American union has written for the reports and asked for an elaboration of the ideas. It would be disturbing to believe that British unions are less progressive, and less aware of the need for co-operation in these vital fields.

It cannot be emphasised sufficiently that skill depends entirely on information and that the future will demand the highest skill in management labour relations. In the present state of affairs, the required facts can only come from investigation by independent and impartial institutions with a main interest in fact finding, rather than grinding the various political or economic axes. The required facts extend over many different channels of communication which are clearly inadequate at the present time for the conduct of modern industry. It seems vital that they should be obtained, and carefully studied by both sides of industry with the long-term implications in mind, before we embark too lightly on much further jostling at the trough.

IV. The future of human engineering

The skills of the future will be determined in part by developments in human engineering. There are still many obstacles, already discussed, but there is no real doubt that the findings will play an increasing part, and conceivably in the very near future.

The work in presenting information and of arranging optimal methods of control and display to link man and his machines or work space will undoubtedly continue. But the problems of the transfer of skill are probably of far greater immediate importance, in view of the need to re-employ an ageing population and the redeployment of workers as automation develops.

The immediate problems of training or re-training fall under three main headings. The first is the simplest, because a great deal is already known about it and the methods are direct. The problem is to design machines so that the habitual skills of everyday life show the highest possible transfer to their use. This will by itself reduce learning time, increase the number of people who can learn, and reduce the risk of accidents when the operators are under stress. A simple example is that the frequent use of domestic taps develops the expectation that anti-clockwise motion will increase water flow, and conversely. But many steam valves and other devices use exactly the opposite convention. This convention certainly increases learning times, but there is no known evidence concerning the effects on accidents in these particular cases.

There is such evidence, however, with more complex examples. Control levers of the joystick type are often used to control machines which move in two dimensions. Two different conventions are possible to relate (a) the direction of joystick movement to (b) the resulting movement of the machine. The machine may move in the same direction as hand movement, and this convention makes full use of the habitual skills of moving an object with the hand, pointing at a moving object, writing, and other everyday skills. But this convention is not favoured by many engineers. They argue that a joystick is usually a lever pivoted in the middle and, considered in this way, it is natural to point the far end of the lever in the direction in which the machine should travel. This then entails the opposite convention, that machine movement is the reverse of hand movement. This argument has now raged for many years and is entirely analogous to the controversy about the horse's teeth, since it is so much easier to find out than to argue. It therefore seemed useful to set up experiments to decide the matter, and these were carried out about 10 years ago. The clearcut answer was that the convention which may seem natural to engineers who understand a machine's construction is highly unnatural to the average operator who lacks this background. His learning time is greatly increased and he may well make mistakes under stress, if a given direction of limb movement leads to opposite motion of the machine. This inefficient and unnatural relationship is still widely produced, however, and used in various public services who have certainly received the reports. Apparently, the learning aspect still seems unimportant to many engineers. But in personal experience, there have been serious and tragic consequences when men have been transferred at short notice between machines which use different conventions. Machines with different and opposed relationships of this kind are widely found in close proximity, and this is far more dangerous than standardising either.

The classical example is perhaps a mechanised trolley used for coal transport underground. The machine cannot be turned around underground in the confined space, so the simplest system is to provide seats facing opposite ways and pivot the steering wheel, so that it can be positioned

appropriately for either direction of travel when the driver changes seats. But the result is that the directional conventions used in steering are directly opposed on the journey to, as compared with from, the pit head and, moreover, the positions of the brake and accelerator pedals relative to the driver's feet are completely reversed. Such arrangements are, without doubt, as criminal as designing a car without brakes, and apart from considerations of slightly reduced costs have nothing to commend them.

A second problem in the transfer of skill arises in the use of synthetic training devices, which are widely used in the armed services. A particular use is for the preliminary training of aircraft pilots, but they are in very general use whenever initial practice on the real machine is precluded because of time, cost or risk. They are also used to teach emergency and similar procedures for which the real machine is unsuitable, or to give the occasional practice which is needed to retain high skill in some activities.

Devices of this kind could undoubtedly be used far more widely and effectively in industry and other spheres. The current and barbarous practice of allowing car drivers to learn from scratch on congested and dangerous roads is one case from many.

It would be a real social service, and probably a lucrative one, to find how much initial skill could be gained from preliminary practice on a synthetic trainer in the quiet and safety of a room. Again, crane-driving and other potentially dangerous skills might well be taught initially on such synthetic trainers.

There are formidable problems, however, in determining precisely what the operator is learning, his critical difficulties, and how best to simulate them with maximum economy. Current technique in designing such trainers is to make them as nearly like the real machine as possible. This can be a most wasteful procedure with expensive machines, and for a number of abstruse psychological reasons (which need not detain us), it is not necessarily the best method for obtaining high positive transfer. A number of comparative studies have been made. Cases have been found where very expensive simulators with high "face-validity" were, in fact, far less effective than much cheaper devices which concentrated exclusively on the critical point of difficulty. This occurred despite a complete lack of resemblance to the real machine.

The point was well brought out in recent studies of training aids for a machine which has rapidly-acting acceleration controls. Preliminary and frequent refresher training was required, and the real machine was too difficult, dangerous and expensive to allow direct practice. But the requirements were satisfactorily met by training the operator in balancing a steel ball in the middle of a plate.

Synthetic trainers are the same in principle as the predesign simulators already discussed. The problem is to present critical control difficulties as economically as possible. The latter's functions are different, however, since their main purpose is to try out projected engineering solutions and to optimise system parameters before a prototype machine is actually made. They are particularly valuable when new control problems are likely to arise, for example in designing new high speed aircraft. The alternative procedure is to design the machine in the light of previous experience, which may be a dubious guide, when unknown man/machine factors are involved. This procedure ends in inviting an intrepid test pilot to find out whether a human being can actually control the machine. The answer that he cannot may lead to considerable wastage in finance and in far more valuable lives.

It would be idle to pretend that ready-made solutions are available for such problems at the present time. But the future will demand that they be found from much closer collaboration of physical and biological scientists, than is the present case. Such problems clearly merit research and support on a national basis.

"THE COST OF AUTOMATION" — concluded from page 422

will tend to become more and more the things that ought to be done.

Managements are having to look closely at their procedures, designs, etc., and are realising, often with some shamefacedness, that a good deal of their time, effort and expense is being squandered on the unnecessary. More than one management has confessed that this was so, and that changes of routine should have been made long since, quite apart from the question of automation.

It is reasonably certain that there will be better planning, better programming, better scheduling and better information. The old days of reliance on personalities, intuition, crystal gazing, etc., have all but disappeared. There is no doubt that intuition and experience still count for a great deal, but in the higher policy making rather than on the factory floor. On the factory floor, once policy plans have been made, the operating plans, are and must be today, the result of careful methodical study.

This Paper has attempted to suggest some of the problems which will affect the cost accountant, without attempting to produce precise solutions, most of which would inevitably at present be guesses. It is hoped that it will stimulate some discussion.

Perhaps a suitable end is another quotation from Paul Einzig who says: "Woe to him that is left behind in the automation race. He will suffer all the disadvantages of progress without enjoying its advantages."

DISCUSSION GROUP D3

THE ANALYSIS OF INDUSTRIAL BEHAVIOUR

by Professor R. W. REVANS, Ph.D., B.Sc.

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Prior to his present appointment as Head of the Department of Industrial Administration of the University of Manchester, Professor Revans was Deputy Chief Education Officer, Essex County Council; Director of Education with the National Coal Board; and Research Consultant with the National Coal Board, directing research into the management of collieries.

He is a member of the Institution of Mining Engineers, and is the author of a number of publications on physics and astronomy.

THE problems of British industry today lie largely in what seem, at first sight, to be two distinct fields. The first is the field of work organisation, concerned essentially with relations between *processes*, that is with questions of decision-sequences, production planning and control, method study and so forth. The second is the field of industrial morale, concerned essentially with relations between *persons*; in this field are to be found our ideas on strikes, go-slows, absenteeism, accidents, labour wastage, demarcation problems and other suggestions of pathological behaviour. The magnitude of the greatest technical tasks that British industry has ahead of it still falls short of what will be involved in solving these social problems; for many years we shall be fully engaged merely in finding out something of their fundamental causes. It is, moreover, ironical that not a little of the trouble that arises in both of these two fields springs from work situations where technology is most advanced, and where the research of the scientist finds its most fruitful applications. It is not always the technically backward industry, like coal mining or building, which monopolises the scene. One can find disputes leading to a great loss of wealth and of human dignity in industries like motor manufacturing and electrical construction, in which science and technology have reached very high levels indeed.

It is frequently said that the precarious position of the human race at the present moment has been brought about by the rapid advance of technology in a society that has not yet learned to understand itself; science, we are told, has outstripped the humanities, and ordinary men do not understand the proper social use of the tools and weapons that science has placed in their hands. There is some truth in these statements, although it is hardly necessary that we should have to accept this truth as permanent and inevitable. On the contrary, we might be more objective in our study of the behaviour of people both at work and in their leisure, and we might find out things about this behaviour, or about their responses to particular forms of treatment, including management, which would encourage us to develop organised

researches, much as the 'early work of men like Faraday has led to the foundation of schools of research in physics and engineering.

A complex subject

Those who say that the superb achievements of physics were inevitable because physics is essentially a simple subject, whereas the behaviour of men in industry is immensely complicated, are no doubt saying something which also is partly true. The behaviour of men in industry *is* immensely complicated. But this is all the more reason for it to be studied objectively ; it is quite irrational to suggest that because something is difficult and complicated, it should be left to guesswork, while something that is relatively simple and straightforward should be made the subject of precise and accurate measurement.

Our first major field of industrial difficulty, that is, the field of industrial operations and tactics, is beginning to attract a number of eminent mathematicians ; some of you may say they are too eminent and they talk jargon which ordinary men cannot understand. The digital computer, with its binary arithmetic, its sets of differential equations, its matrix algebra and so forth, seems no doubt very formidable. The analysts whose stock-in-trade is linear programming, the theory of queues, Monte Carlo methods and so forth all seem as remote as they claim to be ingenious. The operational research worker trying to import ideas of measure and probability into questions of organisation is, for the moment, using terms that the man in the factory busy with getting things done finds a little puzzling and even a little spurious. But this is merely because these new studies of organisation, of risk, of bottlenecks, of optimum routes and so forth are still a bit novel. But this is merely the marriage of long-established mathematical techniques to industrial processes, and if the country *will* set out to get more scientists into industry, it must expect these scientists to bring novel methods of mathematics and statistics into industry as part of their baggage.

The operational research worker must, of course, be well mannered and must learn to talk about his techniques in language which industry can understand, so that eventually managers at all levels will come to think about their operational problems with the same facility for measurement and order as at present they bring to the consideration of their technical problems. For we shall never get very far with automation, particularly in the field of automatic assembly, unless we give a great deal more attention to the rhythm and regularity of work flow than we commonly do at the moment ; and we must accept the fact that now the scientist has insinuated himself into the field of industrial organisation, it will be the duty of the industrial manager to meet the scientist on his own ground.

In what I have called the second field of difficulty, however, the scientists have not yet got their foot in the door. This vast field of industrial relations is still by and large unstudied, at least by objective methods. Of the forces that determine whether particular groups of men will collaborate with one another and their managers in particular situations we still know very little. Somebody once said, " The striker is unhonoured, unloved, and unsung ; above all, he is unstudied." These are sentiments that should awaken a response in all of us here, and we must not derive false comfort from the pronouncements of Courts of Enquiry. These are purely legalistic exercises ; they may very exactly determine that So-and-so broke such and such a rule when he said this or that to such and such another person ; they may provide an unanswerable analysis of why the blame in such and such a case should be distributed partly to such and such a shop steward or such and such a labour officer. But, since they do not get to the underlying causes of why so-and-so did what he did, they may even make the second situation worse than the first ; for they may give the impression that they now know something about the causes of disputes or of industrial unrest which they did not know before.

In my view, many of these purely legal enquiries are misconceived ; if they do not deflect attention from where it is needed, they may merely smother one form of ignorance with another. Our essential business is not to find out whether some agreement has been violated and, if so, who violated it and what ought to be done to punish him ; we need to determine whether we cannot establish working conditions in which such agreements are not necessary, or, if they are inevitable, whether we can get on without forever being in danger of tripping up over them.

Where to begin ?

It is difficult to know where to begin in this kind of study. We have not yet got the basic concepts clearly enough in our own minds. What we need are a few ideas as simple as, say, those which Faraday brought to his early studies of electro-magnetic induction ; this made possible the rational study of electricity and has ensured the growth of electro-technology. In the same way, Chadwick's discovery of the neutron has made possible the development of nuclear energy. Both of these discoveries, although essentially simple, have led to new ways of thinking about the nature of the physical world.

The study of industrial behaviour is still awaiting its Faraday or its Chadwick. You may say that this is vastly over-simplifying the problem, because Chadwick was dealing with a single entity and Faraday with only two or three simple concepts, whereas in industrial behaviour one must take into account scores of independent factors. But this, in itself, should not prevent the discovery of a simple, hitherto unknown, law. It was almost 100 years ago that Darwin wrote " The Origin of Species " and although this is a long and patiently collected work, the principle which it declares, that is, evolution by natural selection, is essentially a simple one. This principle, which eventually led into his work upon the origin of the human race, deals with just as many

factors as the most tangled industrial situation in the biggest motor works or the most discontented coal mine, and it has probably had an effect upon mankind at least as great as the discoveries of Faraday and Chadwick. All I am trying to say is that the most tangled field can nevertheless be brilliantly illuminated by one new idea. We should not be put off from trying to find simple clues in industrial situations simply because a lot of clever people tell us that these situations are complicated.

If, therefore, the study of human relations in industry is still awaiting its Darwin, we might spend a few minutes asking ourselves what it was that Darwin did. If you remember, he made a voyage of scientific discovery in a boat called *H.M.S. Beagle*. He did this while he was still a young man and he spent the rest of his life in this country sustained by this tremendous experience. The important thing is that while he was in the *Beagle* he collected an immense amount of evidence about how various organisms live, and how they are adjusted to the environment that nourishes them. It was the discipline of these observations and of their classification afterwards which led him to detect what he thought to be the same idea running through the whole of the natural order. Whether he was looking at marine plants, butterflies, lizards, mosses or song birds, he tried to fit them all into simple logical patterns and to detect what these patterns had in common. His success was due to the courageous sweep of his imagination and to his belief in the essential unity of the natural order. I believe that we today have to be just as bold in our study of the behaviour of the human insect in industry; we must look at the picture on a vast scale and draw very simple conclusions. I now want to suggest some of the things we might look at.

My first illustrations are drawn from the coal industry. In Tables I and II are set out some of the facts about industrial disputes in Yorkshire and South Wales. The criterion of classification is the size of the mine by the number of men employed and the variate we are measuring is the tonnage lost per man in disputes; these disputes include both strikes and go-slows. They exclude, however, coal field strikes and are hence a measure of the extent to which the men in the individual mines will withdraw from their work over some disputed issue arising in their own mines. The figures confirm a general impression, namely, that strikes are diseases of big organisations. We often suspect that the big liners, the big motor car factories, and the big steel works are more prone to disputes than the small; these statistics for the coal industry suggest that this thesis is probably true.

It is interesting to test the common explanation of this size effect, namely, that the agitator who wants to stir up trouble or to exploit grievances of other men finds it easier to do so in the big pit. It is said that here he can work under cover and the management find it difficult to identify him or to counteract the rumours that he starts. Some light is thrown upon this suggestion by an analysis of the disputes according to their ostensible cause; if agitation about men's grievances were in fact the explanation of this size effect, one would assume that with increasing size of pit, the proportion of disputes over wages to other

STRIKES AMONG COALMINERS

TONNAGE LOST BY DISPUTES, 1949 - 53, BY SIZE OF COALMINE

Table I — Yorkshire.

Manpower Group	*No. of Pits*	*No. of Disputes*	*Tonnage Lost*	*No. of Disputes per 1,000 Men*	*Tonnage Lost per Man*
Below 500	28	79	42,100	11.1	5.94
501 - 1,000	25	275	168,953	14.6	8.97
1,001 - 1,500	20	386	399,240	15.8	16.39
1,501 - 2,000	21	482	454,285	13.6	12.82
2,001 - 2,500	8	256	282,282	14.4	15.98
Above 2,500	12	824	763,963	24.5	22.70

Table II — South Wales Bituminous Coalfield

Manpower Group	*No. of Pits*	*No. of Disputes*	*Tonnage Lost*	*No. of Disputes per 1,000 Men*	*Tonnage Lost per Man*
Below 500	35	204	123,229	16.0	9.69
501 - 1,000	40	575	437,997	15.9	12.14
1,001 - 1,500	23	525	389,833	20.2	15.01
1,501 - 2,000	6	172	244,321	16.4	23.39

Source: National Coal Board.

Table III

DISTRIBUTION OF 1,726 DISPUTES IN YORKSHIRE, 1949 - 52, ACCORDING TO SIZE GROUP OF MINE AND REPORTED CAUSE

Size Group by No. on Books	*No. of Mines*	*Total No. of Men on Books*	*Reported Causes*	
			Monetary	*Non-Monetary*
Below 1,250	67	42,600	248	162
1,251 - 2,000	30	47,500	262	280
Above 2,000	18	45,500	320	454

disputes would also increase. For it would be expected that the exploiting agitator would tend to choose wages issues as the fuel for his fires; in the large pit, too, there would also be a wider range of wage-differentials, since there are more types of men employed, more variations between one side of the pit and the other, and hence more room for comparisons between rewards for superficially equivalent tasks. This, you might say, explains the size effect in disputes. The figures, however, show the very opposite effect. In Table III is set out an analysis by wage and non-wage issues of the 1,726 disputes which occurred in the Yorkshire coalfield in the four years 1949-52.

This has been classified in a slightly different way from the data of Tables I and II; the coalfield has been divided into three roughly equal classes of men: that third working in the 67 smallest pits, that third working in the 30 medium pits, and that third working in the 18 largest pits. It will be seen that although there is the largest number of disputes over wages in the class of largest mines, the size effect for the non-wage issues is far more strongly marked. In other words, the Yorkshire coal miner in the largest mine of all is but slightly more inclined than his brother in the small mine to enter into a dispute over his wages, whereas his inclination to argue about issues other than wages is about three times as great. We may conclude from this extremely cursory examination of the facts that the size effect is very far from being a wages effect; this suggests that it cannot be imputed to agitators.

Accidents among coalminers, quarrymen and nurses

The second set of illustrations is about the size effect on industrial accidents. Sigmund Freud suggested that people have accidents only when they want to have them, that is, when they find themselves in situations that they want to get out of. Again, I illustrate this thesis with figures drawn from the coal industry and in Table IV are set out some accident statistics for all the coalmines in South Wales during the year 1950. They show that the risk of having an accident if one is a miner in a large mine is about eight times as great as the risk of having one in the same period of time if one works in a very small mine.

It might be argued that the accident risk in the mines employing many men is high because these big mines are deep and highly mechanised; it is argued that machinery adds to the risk of injury. But this is not so. If one compares in any given year the accident rates in mechanised and non-mechanised

Table IV

DISTRIBUTION OF ALL ACCIDENTS DISABLING FOR MORE THAN THREE DAYS AT ALL COALMINES IN SOUTH WALES, 1950, BY SIZE OF MINE

Size of Mine by No. of Men on Books	*No. of Mines in Sample*	*No. of Accidents*	*Total No. of Manshifts* (000's)	*Accident Rate per* (000's) *Manshifts*
Less than 4	41	5	21.66	23.1
5 - 8	20	11	29.18	37.7
9 - 16	22	33	63.25	52.2
17 - 32	20	86	110.7	77.7
33 - 128	10	242	206.3	117.3
129 - 256	25	2,005	1,348	148.7
257 - 512	42	6,336	3,844	164.8
513 - 1,024	68	21,664	12,865	168.4
1,025 and over	23	15,267	7,631	200.1

(The expected size groups 33 - 64 and 65 - 128 have been amalgamated since there are only 10 mines altogether in the two groups.)

Table V

DISTRIBUTION OF ACCIDENT RATES BY SIZE OF QUARRY

ALL BRITISH QUARRIES, 1950

Size by No. on Books	*No. of Quarries*	*Total No. of Accidents*	*Rate per* 100,000 *Manshifts Worked*
Less than 8	2,037	224	12.6
8 - 12	417	204	18.6
13 - 16	309	240	22.4
17 - 24	342	367	22.0
25 - 32	187	380	29.5
33 - 48	156	430	28.9
49 - 64	91	383	30.8
65 - 96	53	329	32.2
97 - 128	30	264	33.1
129 - 256	31	436	35.2
Above 256	5	433	48.1

mines working the same seams, one finds that the non-mechanised mines have the higher accident rates. One cannot, of course, have an accident with a coal cutter in a non-mechanised mine which has no coal cutters in it; nevertheless, the overall accident risk remains higher in the non-mechanised pit. But it is quite simple to show that the size effect is not due to geological conditions on the hypothesis that the big mine has a higher accident risk because it is deeper, and with thicker seams or more difficult working conditions. This can be shown by methods of partial correlation, although we need not pause to study such sophisticated arguments. In Table V are set out some accident statistics for all British quarries in the year 1950. This shows that the risk of injury depends strongly upon the size of the quarry and in these, whatever their size, all men work in the open air. Only a very few accidents occur on the working face, so that one cannot attribute the high accident rate in the big quarries to men falling on precipitous crags. It is something about working in the large community that must account for the liability.

These arguments may still not convince those who believe that accidents are purely environmental events precipitated either by the danger of the work or by neglect of technical precautions called for in that environment. On this account, I have set out in Table VI the accident rate in nearly 5,000 American hospitals for the year 1953. Hospitals are even more different from coalmines than are quarries, but Table VI shows that there is a very strong size effect. The nurse, laundry worker, ward orderly and other hospital employee is six times as liable to have an accident in a big hospital as in a small. Hence, the

Table VI

WORK-INJURY FREQUENCY RATES IN AMERICAN HOSPITALS, 1953, BY TYPE AND SIZE OF HOSPITAL.

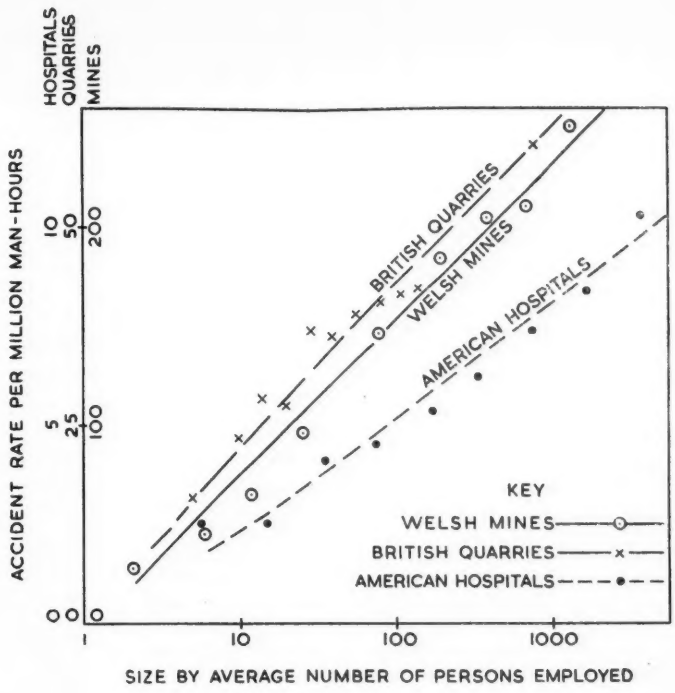
Size of Hospital by No. of Employees	*Accident Rate and Size of Hospital*				
	General Hospitals	*Mental Hospitals*	*Tuberculosis Hospitals*	*Special Hospitals*	*All Hospitals*
Less than 10	2.5	6.3	7.5	2.9	2.6
10 - 19	2.5				3.2
20 - 49	4.1		9.1	9.3	5.0
50 - 99	4.5	8.1	7.4	6.7	5.1
100 - 249	5.3	7.6	8.0	8.6	6.0
250 - 499	6.2	8.7	12.6	9.5	7.3
500 - 999	7.4	15.4	16.4	13.4	10.0
1,000 - 2,499	8.4	21.0	13.8	25.5	13.5
2,500 and over	10.3		—	—	12.4

NOTES

(a) The failure of the entries in the final column to rise steadily throughout is manifestly due to the fact that the largest size class contains no tuberculosis nor special hospitals, and probably only a few mental hospitals, since for these the two final cells are bracketed.

(b) Accident rates are in disabling accidents per million employee hours worked.

Fig. 1.



size effect turns up not only in places acknowledged by everybody to be dangerous, like the coalmines of South Wales, but in institutions devoted to the cause of human health and security.

It is interesting to put the results of Tables IV, V and VI upon one diagram and this I have done in Fig. I. This suggests that apart from what might be called a coefficient of scale determined by the technical task being done, the functional relation between size of the institution and the accident risk to the individual is precisely the same. There is, in simple language, the same relative trend for Welsh coalminers and the employees of American hospitals to get hurt more in the bigger places of work. Perhaps the most interesting conclusion of all is got by producing the lines of Fig. I backwards to cut the size axis, that is, to determine the size of unit at which the accident vanishes. In all cases it is the unit employing one person. Does this suggest (since such units do not exist) that accidents are almost wholly social events, caused by trying to get people to work together?

Absence from work among coalminers and telephonists

My third set of illustrations of the size effect on industrial behaviour is drawn from the statistics of absenteeism. As is well-known, these statistics are frequently most unreliable and those of absenteeism among coalminers are probably most unreliable of all. Certainly any distinction between voluntary absenteeism (the deliberate absenting himself from work of a healthy miner) and involuntary absenteeism (the absence of the miner on the sick or injured list) is not a distinction on which any prudent man would attempt to base conclusions about patterns of attendance. But the figures of total absenteeism, that is, the relation of all shifts lost to all shifts that could have been worked, whether by men at the coal face, elsewhere underground or on the surface, all expressed as a percentage, enable us to see whether the size effect is significant in determining how far men are willing to turn up to work. Table VII gives some figures which show that the size effect is extremely powerful. They express the average percentage absence in all small mines, that is, mines employing between 10 and 100 men, on the one hand, and all large mines, that is, mines employing over 1,000 men, on the other. The Table gives the results for the year 1942 by the seven major coalfields; this was the last year before the industry was taken under Government control during the War. It will be seen that in all cases the percentage of absenteeism in the large mines is much worse than that in the small; the difference is highly significant and accounts for about four percentage points of the national average.

Some interesting supporting evidence for this effect which, although not drawn from the same volume of employees, is nevertheless more reliable, has very kindly been given to me by Mr. S. Wood, Chief Statistician to the General Post Office. He has studied the attendance of a sample of girls in large and small telephone exchanges about the country

Table VII

PERCENTAGE ABSENTEEISM IN LARGE AND SMALL MINES, 1942

Coalfield	*No. of Mines*		*Average Absenteeism %*	
	Smaller	*Larger*	*Smaller*	*Larger*
Scotland	108	12	5.65	7.50
Northern	92	45	6.72	8.41
Yorkshire	42	56	10.02	13.73
North Midland	27	35	9.05	14.19
Midland	61	20	7.71	13.45
Lancs. and North Wales	41	21	7.43	13.12
South Wales	79	29	7.51	10.98
Great Britain	450	218	7.15	11.66

and shows that whether the girls are married or single, established or unestablished, their attendance, class by class, is better in the small exchanges. But he has also done something more valuable than this. It might be said that the size effect inheres not in the exchange, that is, not in the working community of girls, but in the social conditions of the areas in which the telephone exchanges are located. In country areas, where life is comparatively leisurely (and telephone exchanges are small) it might be argued that the girls are not subject to so much stress as those who work in the big exchanges in the big towns and that, hence, one would naturally expect the girl in the small exchange to attend better. Mr. Wood, however, has pointed out that there are small exchanges in London and his analysis shows that the effect persists. The girls in the small London exchanges turn up to work much better than the girls at the big London exchanges. His results are shown in Table VIII and IX. It must, however, also be mentioned that further work has shown that the size-effect does not apply to the absence of postmen; this seems to be independent of the size of the office to which they are attached. Since their social contacts are not, at work, with each other this result might be expected.

Need for evidence

All of this evidence — on strikes, accidents and absenteeism — is highly significant ; the results are shown for large numbers of workers and large numbers of institutions. Moreover, the results are not selected from among a compilation of other results which happen not to show the size effect. They are, in fact, the only results which have so far become available to me, because, in general, statistics of this kind are not collected, nor are they analysed and published. The possibility, of course, of theorising about the nature of industrial behaviour depends upon the extent to which such statistical and other evidence can be given to those who are interested in drawing conclusions from it. For this purpose every scrap of evidence is worth having. When, for example, I was asked for my views upon the wastage of hospital nurses I found it extremely difficut to know where to begin, because of the almost complete absence of statistics comparing one hospital with another. But there is a little survey available, made by the Oxford Regional Hospital Board, in which the wastage of both student nurses and of experienced nurses joining the hospital after having qualified elsewhere, has been studied in detail; this shows that hospitals with high wastage of student nurses also

Table VIII

AVERAGE DAYS PER YEAR ABSENT SICK AMONG TELEPHONISTS BY SIZE OF EXCHANGE

Size of Exchange by No. Employed	*CLASS OF STAFF*			
	Married Established	*Married Non-Established*	*Single Established*	*Single Non-Established*
Less than 30	18.7	21.7	10.7	17.8
31 - 100	21.4	24.2	13.7	20.1
Above 100	21.5	29.2	14.3	25.5

(This table omits girls with more than 90 days absence per year. It is prepared from figures for about 3,000 girls out of the 35,000 employed in 1952.)

Table IX

AVERAGE DAYS PER YEAR ABSENT SICK AMONG TELEPHONISTS BY SIZE AND LOCATION OF EXCHANGE

Size and Location of Exchange	*CLASS OF STAFF*	
	Married	*Single*
Small rural	21.7	17.8
Small London	22.4	16.2
Large urban	29.2	25.5

have high wastage of experienced nurses and *vice versa*. Moreover, both of these types of wastage are significantly correlated with the number of persons employed at the hospital. This is further evidence that there is something about big hospitals to which nurses find it difficult to adjust themselves.

Effect of size of working group

One cannot get out of statistics any more than one puts in at the beginning. But the fact that there is something about big institutions that people do not like demands an explanation. If one starts again to compare like with like, that is, big coalmines with big coalmines, one finds that those big coalmines employing big working groups of men are significantly worse in their responses than big coalmines employing small groups of men. Likewise, if one compares medium sized coalmines made up of large groups of men with medium sized ones made up of small groups of men, one finds that strikes, absenteeism and accidents are significantly worse in the medium pits with the large working groups. To cut a long story short, the size of the working group as well as the overall size of the coalmine is a factor in determining the way the men behave.

Management and behaviour of men

One can pursue this argument and show the most important factors in determining the behaviour of coalminers are these factors of organisation; in my view, both the total size of the coalmine and the size of the working group are measures of the extent to which the management can know what is going on and can do something to control it. Where the commands of the managers and foremen are sufficiently compact or sufficiently well set out to enable them to do their proper job of providing the men with what they need to do their tasks, the men will respond by arguing less about the terms of their work, by turning up more regularly to perform it, and by withdrawing less frequently through suffering accidents. It can be shown by rather sophisticated arguments that these factors of management control are more important than what might be called environmental factors, such as the thickness of the coal seam or the depth of the mine. The statistics cannot, of course, say what it is that the management in the smaller or more closely organised mines can do which their colleagues in the larger or more loosely organised cannot do, but field studies of what actually goes on in the large pits suggest that the source of trouble is failure of communications. This is a simple concept: a manager distributes his authority around the coalmine, telling such and such persons that they may settle such and such matters. It is then the business of the organisation to see that information about these matters gets to the people who are empowered to deal with them. In a large and loosely knit organisation this communication becomes difficult. In consequence, the management is aware that operational problems exist without knowing precisely what they are, while the miners may get the impression that the organisation is haphazard or even slipshod. When this occurs the men are kept waiting from time to time either for supplies of materials, for repairs to broken machinery or for a conveyor belt to be restarted and take away the coal which they are filling. In the worst cases, inadequate supervision at the heart of things, such as at the telephone exchange or in the manager's office, will keep the whole pit in suppressed exasperation. Men feel it to be an insult to their self-respect to work in an organisation where nobody seems to understand what is going wrong; the large unit is most susceptible to these failures of communication and it is there that the failure of morale is most likely to occur.

Industries other than coal cannot derive consolation from the fact that they are normally better supervised than the pits. The average density of persons concerned with collecting, classifying and transmitting information in the engineering industry is, for example, about five times what it is in coal. The problem of getting the right information to the decision point when it is needed still, however, remains. Moreover, the danger is not infrequently the opposite one, namely, that there are too *many* people handling different facts about the same working situation; the result is disorganisation in a different form. In the coalmine the trouble is that the officials in the line of authority are grossly overworked and have not the time to pass information upwards to those empowered to act upon it. We might call this a tendency to vertical disruption. In the engineering shops, however, although the foreman may still have plenty to do, he usually finds the factory equipped with a number of staff systems, all of which collect and process information about his work. There is, firstly, the production control system, with its close ally the progress system; there may be a work study

department, a standard cost office, a personnel department, a labour cost control system, an inspection department, and even one or two more self-contained developments of what we are mistakenly pleased to call "scientific management". Most of these, where they exist, have appeared in the last seven or eight years; all of them to some extent work within the same sphere of authority as the foreman. But in practice their responsibility is not to the foreman, but to the head of the particular staff system; he, in turn, is normally responsible to the works manager. Each one of these staff officers may depend upon other important contacts which do not directly affect the foreman; the drawing office, the estimating department, the buying department and so forth pull a tangle of wires somewhere behind the lot of them. The co-ordination of this system of systems is sometimes good, sometimes mediocre and sometimes bad. There is then a tendency to what might be called horizontal disruption, and in big organisations we may find this imposed upon the vertical disruption that is a common feature of large organisations with large working groups.

But all this is speculation. One cannot enter into the consciousness of a workman; it is hard to explain why in some conditions he will work hard and continuously, while in others he will follow his mates into a strike that seems ill-timed, misconceived and offers profit to nobody. It is easier to attribute all industrial unrest to its ostensible cause, namely, dissatisfaction about wages. The analysis of this Paper shows, however, that size, which is explained here as the degree of dilution of the manager's ability to take the appropriate operational decision, is more important than wages in determining what shall be the temper of the men. Indeed, a study made of the average wages per shift paid during 1953 to the miners showed that there is no significant difference between the average of those in the pits that go on strike and the average of those in the pits which do not go on strike. The actual difference of about 1/- per shift in favour of the non-striking pits can readily be explained by the loss in bonus payments to those men in the pits that are the seat of trouble. Where men lack confidence in the ability of their managements to manage, they will express this lack in the only way open to them, namely, in an application for higher wages. Where there is only one battle field one must expect all battles, whatever their cause, to be fought upon it.

The place of joint consultation

We have heard much since the War of the importance of joint consultation as a means of bringing the men into the processes of management. Theories of joint consultation assume, however, that men *wish* to be consulted upon these affairs. It may very well be that a handful of them do, but for every dozen men in a coalmine who are interested in helping the manager to decide how to run it, there are probably a thousand who are more concerned to feel that their particular section of it is properly organised so that they do not have to waste their time or do unnecessary tasks. Hence, joint consultation concerned with overall administrative issues is not likely to appeal to more than a few; the majority want to know why it is that a particular instruction or a particular set of spares or a particular load of timber was misdirected at some time on a particular shift, because it was this specific failure which caused them embarrassment, inconvenience, or even loss of earnings. It is this kind of detail that joint consultation, as it is generally attempted, was never designed to handle; it cannot be handled except by local consultation with that part of the management organisation in charge at that particular point. Such local consultation demands, not new formulas or new committees, but a new attitude towards the delegation of authority. What might be called the smoothness of the horizontal flow of work and the willingness of the men to do that work are inextricably mixed. Hence, the division of the field of industrial problems with which I began this talk is an illusion. There is one field of difficulty alone. Human relations in the factory depend upon the extent to which men perceive the work to be economically and effectively arranged; where this is not so discontent will arise and it may eventually break out in a dispute.

The optimum level of problem

The picture I have drawn is, of course, a gross over-simplification. Indeed, we all know that organisation can be taken too far and that then men may again revolt. These cases are rare but they nevertheless exist. Their explanation is, I believe, along the following lines: to derive satisfaction from work one normally needs to use one's intelligence in solving the little problems that arise from time to time. There is an optimum level of problem for all workers; with some even a simple challenge is too severe, with others a most difficult problem immediately attracts their whole attention. But if for any particular person the challenges are too difficult for him to meet, he will become discouraged and will give up. This I believe to be the case where the forces of vertical and horizontal disruption, as in the large and complex unit, are considerable, and where the work appears uncertain and ill-planned. When, on the other hand, the challenges that the individual encounters are too easy, his interest will flag and will become bored. When he is bored he will find opportunities for escape from his boredom and these will normally take the form of organised revolt.

This is frequently the situation where, by intensive time and motion study or by other tightly controlled systems, the individual worker is left with no problems on which to exercise his ingenuity. The over-organised factory impairs his freedom of thought and decision; the under-organised factory fritters away the active hours of the life that he, like all of us who deplore wasting time, can live only once. It is the task of management to see that its authority is distributed in such a way as to give all employees, both workers and foremen, the level of problems which they can settle by taking thought or by consulting other people; it is to find, and to use, the most effective distribution of

authority that the methods of operational research must be employed. Management, in other words, must study not only systems of technology, of selling, of costing, of training, of reporting and so forth ; it must study the articulation of them all into its business of management. It must, above all, not be afraid to give authority to its subordinates.

I want to leave you with the thought that it is the articulation of all these management systems and techniques which will ultimately determine the relations which exist between the manager and his men. To use an analogy in electrical engineering, we are like men who know a great deal about inductance, capacity, resistance, potential and the square root of minus one, but we have yet to see that all these may be related to time in such a way as to give something much more useful than the sum of all these concepts alone. The marvellous properties of alternating current lie in the relations between these factors, not in the factors themselves. I believe that if we attend to the first of our fields of major problems, namely, the systematising of our systems by carefully thought out schemes of delegation, we shall find that we have very largely solved the problems of our second field, namely, those of improving our levels of morale.

The problems of men at work are, in my opinion, not so much in the impact of technology upon the individual men as in its impact upon their social groups. It is in meaningful membership of these alone that ordinary men find satisfaction ; when this membership is denied them, when to them the factory offers a life that appears haphazard, uncertain and, not infrequently, grossly unfair, they will revolt against those whom they hold to be responsible. And when this happens the occasions of their revolt will always seem to be in claims for more money or for more perquisites. But since these claims are frequently no more than compensations for what they really need it is not surprising that, having won those claims, they are still not satisfied. If, in the coming generation, British industry is not to be paralysed by the continuous rebellion of outraged human nature, it must pay attention to what, apart from economic rewards, it has to offer those who serve it. A comparison of the small firm with the large may suggest to us what this is.

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concentrate on essential content. It follows, therefore, that as no alternatives are included, all the subject matter must be taken.

An opinion has been expressed that we are expecting too much from students for them to have to study for and take seven hours of examination at the Part III stage. These critics constructively suggest that a thesis be accepted in lieu of an examination. The Education Committee rejected this idea largely on the grounds that past experience showed it to be impracticable. We did think, however, that the basic thought behind the idea could be developed in the future on the lines of " projects " set by colleges and universities and undertaken under supervision, probably with a time factor involved. This idea will not be immediately available in the revised examination, but may be possible in the future as colleges develop their own research activities and as universities awaken to the need for production engineering education.

It is hoped to finalise the structure and syllabuses by the Autumn of this year ready for publication as soon as Council approval has been obtained. As before, students will be able to obtain exemption from the Institution's examination by virtue of other educational qualifications and as soon as syllabuses are complete a revision of the schedule of exemptions will be made.

I hope the members of the Institution will find this Chairman's survey of the revision of the Associate Membership examination of interest, and will take the opportunity for constructive criticism while there is time for it to be considered.

Production management today is a complex and arduous job demanding the highest technical and personal qualities of the men in control. It is clear that the present supply of production engineers is quite inadequate and that it is unreasonable to expect men to be satisfactorily trained by part-time courses to meet the challenge ahead. This means a substantial increase in full-time training is essential and it is most gratifying to find sandwich courses being adopted at an increasing pace. The development of sandwich courses for the new Diploma in Technology will help to meet the need and it is hoped that all the selected colleges will institute a course in production engineering. The universities can also help by developing first degree courses with a production engineering bias, combined with a post-grraduate course devoted entirely to production engineering subjects.

The Education Committee hope that their efforts of revision of the Associate Membership examination will be of help to educational institutions, because only by close collaboration of all the interests can the future challenge be met.

REPORT OF THE STANDARDS OFFICERS CONFERENCE

London, 9th May, 1957

THE impact of the proposed European free trade area on the preparation of industrial standards, and on the work of the men who use these standards, was underlined by a speaker at the third annual Conference of Standards Officers held in London on May 9th last.

In evolving and applying good industrial standards the United Kingdom "has been able to lead and guide the continent of Europe — particularly through British participation in the work of the I.E.C. (International Electrotechnical Commission)", said the speaker. "We must continue our efforts if we are to educate the Continent up to our standards rather than let our standards drift down to some of theirs", he continued.

These observations arose from a discussion on "international standardisation" introduced by Mr. Gordon Weston, B.S.I.'s Technical Director, in which he referred to the growth of other national standards-making bodies whose specifications often had the authority of Government backing.

In the interests of Britain's export trade it was valuable when international recommendations were being considered to have a good British Standard already in existence, said Mr. Weston; in a number of instances, a British Standard had formed the basis for international specifications.

Discussing some of the difficulties of international co-ordination of standards, Mr. Weston referred to the differences in terminology among the English-speaking countries, and to efforts now being made towards greater uniformity between the Commonwealth countries and the United States in such spheres as acoustics, plastics, rubber and nuclear energy. Another difficulty was the inch-metric problem; in some standards, at least, it would be necessary to maintain both inch and metric series.

With reference to screw threads, another speaker said that, in view of Britain's trade with the Continent, it would be better for some companies if they were to go over to the metric system rather than that they should adopt the unified thread. Mr. Weston reported that at a recent international standards meeting in Lisbon, the unified thread had been agreed for adoption in international standards as the only inch alternative to the metric series. The proposal had been supported by a number of Continental countries, including the Netherlands, Sweden and Finland.

Over 200 delegates present

This year's meeting of engineers and others responsible for preparing and applying standards was the third of such conferences and was far larger than the two previous gatherings. There were nearly 200 present from manufacturing concerns in all parts of the country, from the nationalised industries and Government departments. A special welcome was extended to representatives from five technical colleges. The meeting, organised jointly by the Institution of Production Engineers and the British Standards Institution, was held at Church House, Westminster, under the chairmanship of Mr. H. Stafford, of United Steel Companies, and Chairman of the Standards Committee of the Institution of Production Engineers.

An important item on the agenda was concerned with stimulating interest in "the three S's" — standardisation, simplification, and specialisation. Mr. H. A. R. Binney (Director of B.S.I.), introducing this subject, referred to the series of successful meetings held last winter under the leadership of Professor H. W. Martin, the American authority on standards engineering. "Variety", commented Mr. Binney, "is regarded as the spice of life, but to have, for example, several different kinds of sockets for electrical connections is not real variety. We need to speak of the elimination of unnecessary diversity rather than reduction of variety", he suggested.

Mr. Binney referred to the provision of training courses for standards officers at technical colleges and universities. Two such courses had been held as part of Professor Martin's programme — at the Regent Street Polytechnic and the Manchester College of Technology. Further courses were planned by these and other colleges and B.S.I. was keeping in close touch with the Ministry of Education. An international seminar on the three S's is being held in Holland from July 15th to August 17th.

From the discussion which followed, it became apparent that the technical colleges required guidance from industry itself on the kind of courses required, both at the technical and management levels.

A speaker commented that the principles of standardisation were the same whether electrical equipment or office stationery was involved. He believed that a curriculum in standards technique could be drawn up for engineering colleges and he

said that as standards officers they should be prepared to provide lecturers.

Suggestions on coding

Progress with work on coding was reviewed. Since the last conference a special panel had considered three main problems:

(1) *Code numbers for products.* — The panel thought it impracticable to evolve a code which would identify every item used by British industry; the most practicable method would be to use British Standards as the basis of a national system of coding, leaving individual firms to prepare their own detailed codes.

(2) *Numbering of British Standards.* — The panel considered whether any new system of numbering standards might help in coding by supplying an element of significance in the numbering system; it was decided that there was no justification for altering the present system.

(3) *Indexing the contents of British Standards.* — The panel believed that an attempt should be made to index the main contents of British Standards. In many cases these contents, which often carry the authority of a British Standard definition, are not readily traceable by the title of a British Standard and may also have a wider application than the particular standard in which they occur. The panel thought that a card index system for this type of information could be made available to B.S.I. subscribers.

Summary sheets

The 1955 Standards Officers' Conference had recommended the preparation of summary sheets as supplements to British Standards. The first of these — extracted from B.S. 1768 — had been issued and others — extracted from B.S. 1981 and B.S. 1083 — would be published shortly, it was reported by Mr. Weston.

A speaker said the production of sheets should be drastically speeded up to bring in, among others, bolts and nuts, washers, limits and fits, splines and serrations.

The Chairman intervened in the discussion to explain that summary sheets were designed more for the smaller firm which did not have its own standards department, and should be regarded as an additional reference to, not as a replacement of, British Standards.

The standards department — how it works

'The role of national and company standards' was discussed in two Papers, in the first of which a standards engineer discussed the part they played in a large producing organisation.

He regarded his standards department as being primarily an information service. In the larger organisation — particularly where there were a number of different factories, some possibly abroad — it was often difficult to let the left hand know what the right hand was doing. The standards department was useful in spreading information and putting people into touch with each other.

The speaker listed three objectives for the standards department:

1. saving time — by presenting information "on a plate";
2. concentrating demand — through limiting the range of purchasing departments;
3. preserving quality — by keeping up-to date records of new developments in standards and other fields.

He said that the job of the standards officer was to obtain information, interpret that information and present it complete to the designer. "We have to make standards available to people in a digestible form. The standards officer does a job which other people have no time to do."

In the second Paper, another standards engineer spoke on "Standardisation for Large Users". The advantages of simplification and standardisation were recognised by the big process industries as a way to cut down expenses. His company had begun many years ago to economise in materials, to prevent materials becoming redundant and to deal with stores and stockrooms which would otherwise have been piled high. "If this early effort had not been made, the buying departments would be double or quadruple their present size."

The speaker then went on to explain that a huge catalogue had been compiled of every piece of equipment used by his company in all parts of the world. Such items were easily identifiable to a shipping clerk in Singapore, as well as to buying clerks in London.

"Cataloguing is the heart of standardisation", he said. "The basic principle must be: one item, one number, many end-users."

EDUCATION AND THE PRODUCTION ENGINEER

A progress report of the revision of the Associate Membership examination, from the Chairman of the Education Committee, Mr. R. RATCLIFFE, M.B.E., M.Eng., M.I.Mech.E., M.I.Prod.E.

THE Education Committee of the Institution will shortly submit a revised Associate Membership examination to Council and it has been suggested that I, as Chairman of the Education Committee, should give the membership a progress report in advance of completion of the task of revision. I think the Journal provides an excellent medium for such a presentation. I must emphasise that the proposals outlined in this report are not yet firm and are under active consideration by the Committee. Indeed, if any member cares to write to the Education Officer about the proposals, such comment will be put before the Education Committee.

The need for revision of the Associate Membership examination stems, firstly, from the Council policy of broadening the base of the Institution membership in view of the ever-increasing range of industries in which production engineering is an essential part; secondly, from the need to keep pace with the rapid and significant technical and social changes of recent years; and, thirdly, from the need to match the clear emergent stature of the professional production engineer. The consequent task of revision has been long and difficult.

The Education Committee made an early policy decision that the revised examination should cater for production engineers in the broad field of the metal-working industries, whilst production engineers in other industries could gain exemption from Parts I and II of the examination provided they had qualified by examination of equivalent standard in the technology of their industry.

One of the major problems was how to achieve a satisfactory balance between subjects of basic engineering science, production technology and management, and yet keep the examination within the confines of reasonable length and range. During our deliberations we did not forget that colleges have their problems and need freedom to design courses which have an inherent balance, which cater for local conditions and which aim to develop methods which have a liberalising influence on technical education. We were aware that a student attending a course of study as distinct from studying a subject has the benefit of an overall discipline and influence that formal examinations can never assess. The proposals so far formulated by the Committee are the outcome of discussion and proposition, counter-proposition and amendment, second thoughts and new approaches and, eventually, of compromise.

It will be seen from the accompanying Table comparing the existing and proposed examinations that the three-part structure has been retained but with two groups A and B in Part II.

Part I has been extended from five to six papers, each of three hours' duration. Physics has been added as an essential basic science subject for many of the subjects in Part II. Chemistry has been brought in as an alternative to Production Processes (a subject developed from Workshop Technology) for students engaged in metallurgical production fields.

Part II *Group A* continues at a more advanced level the basic engineering science subjects to which mathematics, an increasingly necessary subject in a number of fields, and applied physics and applied chemistry have been added. The two latter subjects not only extend the study of basic theory, but provide the means of developing a comprehensive group of subjects covering the wide range of the metal producing and working industries. Advanced Applied Mechanics has been developed from the previous subject of Materials and Machines. One subject only is taken from this group.

Part II *Group B* comprises the specialist technologies. The metal-cutting group subjects of Theory of Machine Tools, Tool Design and Metrology remain with revised syllabuses. The metal forming group is replaced by Production Metallurgy which covers the melting and casting of alloys, the shaping of metals and alloys, the joining of metals, corrosion and machineability. Plastic Technology is replaced by Non-Metallic Materials, the syllabus for which has not yet been prepared. The intention is to cover a wider range of materials than plastic and to cover properties, testing methods, and applications. Help from experts in this field would be welcome.

Control Engineering Technology has been added in view of the steady development of automatic

control systems, transfer techniques, extended mechanisation, instrumentation and the introduction of data processing equipment.

Process Planning and Work Study was previously catered for in Part III, but one view is that Part III should be concerned with the managerial aspects of application and control of "tool subjects" rather than the techniques and detailed content.

Factory Layout (including Materials Handling), deals comprehensively with the design of manufacturing systems and the range of materials handling. This subject has been developed to meet a substantial demand and undoubtedly will be welcomed by colleges and industry alike. The Materials Handling Division of the Institution are particularly interested.

Consideration is being given to the probable addition of another subject dealing with Applied Statistics including Statistical Quality Control and Operational Research. In the event of this inclusion it would be necessary to group this subject with Factory Layout, Process Planning and Work Study and allow only one of the three subjects to be taken in the examination, otherwise the range selected would be ill-balanced as a whole. Opinion on this aspect would be welcomed.

It is proposed at present that three subjects be selected from Group B.

Part III has been substantially reshaped and strengthened, but with only one-hour extension of examination time. The basic administrative and organisation subject matter has been gathered under "Industrial Administration" with a three-hour paper. The management content is covered in two separate two-hour papers, and an endeavour has been made to cover the art and dynamic of management as well as its techniques. The Committee thought that this part of the examination was the most important for production engineers and should

(*concluded on page* 457)

THE INSTITUTION OF PRODUCTION ENGINEERS

DRAFT PROPOSALS FOR THE ASSOCIATE MEMBERSHIP EXAMINATION

REVISED STRUCTURE			*EXISTING STRUCTURE*	
Part	*Content and Requirements*	*Subjects*	*Content and Requirements*	*Subjects*
I	***Six*** *3-hour papers*	(a) English (b) Mathematics (c) Applied Mechanics (d) Engineering Drawing (e) Physics	*Five* *3-hour papers*	1. English 2. Mathematics 3. Applied Mechanics 4. Engineering Drawing 5. Workshop Technology
	One to be selected from (f) and (g)	(f) Production Processes or (g) Chemistry		
II Group A	*Four* *3-hour papers*	(h) Advanced Mathematics (i) Advanced Applied Mechanics	*Four* *3-hour papers*	1. Materials and Machines 2. Metallurgy 3. Applied Electricity
	One to be selected from (h) to (m)	(j) Metallurgy (k) Electrical Technology (l) Applied Physics (m) Applied Chemistry	No. 1 is compulsory	
Group B		(n) Theory of Machine Tools (o) Tool Design (p) Metrology		4. Machine Tools 5. Jig and Tool Design 6. Metrology
	Three to be selected from (n) to (u)	(q) Production Metallurgy (r) Control Engineering Technology (s) Non-Metallic Materials (t) Process Planning and Work Study (u) Factory Layout and Materials Handling	Plus three to be selected from 2 to 11	7. Press and Sheet Metalwork 8. Welding Processes 9. Hot and Cold Forging 10. Foundry Processes 11. Plastic Technology and Presswork (Plastics)
III	*One* ***3-hour paper*** *Two* ***2-hour papers***	(v) Industrial Administration (w) Management of Production (x) Management of Men	*Two* *3-hour papers*	1. Introduction to Industrial Management 2. Production Planning or 3. Work Study

THE TECHNICAL AND SCIENTIFIC REGISTER

This article has been specially prepared for the Journal by the Ministry of Labour and National Service.

DURING the War, the Technical and Scientific Register of the Ministry of Labour and National Service was the main instrument in carrying out the decisions of the Technical Personnel Committee which, under Lord Hankey's chairmanship, dealt with questions relating to the demand and supply of technical personnel of professional or near-professional standards, including the determination of priorities in demands for such personnel, its economic use, and measures for increasing the supply. There were compulsory registrations of professionally qualified scientists and engineers, through which the Register built up a comprehensive record of scientific and engineering manpower in the country, which was of great help in ensuring that this kind of manpower was distributed and used to the best advantage.

Registration with the Technical and Scientific Register is no longer compulsory, and the Register forms part of the Employment Services of the Ministry. Its main functions at the present time are :

1. to assist employers seeking professionally qualified scientific and engineering staff in meeting their requirements ;
2. to assist professional engineers and scientists, whether unemployed or seeking a change of work, in finding a suitable job ;
3. to collect information about the supply of scientific and engineering manpower and the demand for it, and advise on this subject when required ;
4. to give advice about careers in the various branches of engineering and science ; and
5. to administer the deferment arrangements for science and engineering graduates.

In 1956 the Register carried out an inquiry, in conjunction with the Advisory Council on Scientific Policy and with the help of the Social Survey, into the number of qualified scientists and engineers employed in this country, and the probable future demand for them, both in the short and long term. The results of the enquiry were published by H.M. Stationery Office in October, 1956.

For obvious reasons the Register has had to lay down certain minimum qualifications for persons seeking to enrol with it. These qualifications are, in general, the possession of a university degree in science or engineering, or membership of a recognised professional institution.

Because it deals only with professions in which highly specialised qualifications are required, and because the market for professional men is a national rather than a local one, the Register is centralised in London. A representative of the Register is permanently stationed in Glasgow.

The Register is organised in seven sections, each staffed with professionally qualified officers. The subjects dealt with by the various sections are respectively :

1. physics and mathematics;
2. mechanical engineering;
3. electrical engineering;
4. civil engineering;
5. chemistry, chemical engineering and metallurgy;
6. biological subjects, agriculture and veterinary surgery; and
7. architecture, surveying and estate agency.

The Register as a placing service

The number of persons enrolled on the 'live' Register has remained fairly constant for some years at about 4,000. Of this number about 75% are in employment, but are for various reasons seeking alternative work. This does not mean that the composition of the Register has been static. In 1956, there were 5,700 fresh and renewal registrations, off-set by 5,700 withdrawals, the latter figure including those who were found employment. There is in fact a fairly rapid turnover of young scientists and engineers, some of whom may have enrolled shortly before they qualified. On the other hand, the older scientist and the engineer is not immune from the general difficulty which the older worker has in finding employment.

The figures quoted in the preceding paragraph include women as well as men. The number of women registrants is comparatively small, about 7% of the total, and most of them are under 30. Very few of them are registered as engineers.

In 1956 the number of placings effected by the Register was 1,570, including 303 placings of mechanical engineers, 175 civil engineers and 156 electrical engineers.

The Register is no exception to the rule that the success of an employment agency depends on the extent to which it is used by employers and those seeking employment, and it is constantly aiming to widen its contacts with both parties. For some years the number of vacancies notified to the Register has been sufficient to offer a wide choice to suitably qualified men ; at any time there are about 4,600 vacancies on the books, of which more than half relate to engineering. Whilst the majority are open only for a short period, vacancies are frequently notified by employers who are prepared to wait a long time in the hope of finding a really suitable man.

It is perhaps unnecessary to add that the Service provided by the Register is entirely free.

Careers advice

Through the information it receives from its contacts with outside bodies and with industry, the Register is in a position to give valuable advice on careers or employment to those entering or engaged in the science and engineering professions. The Register does not normally come into contact with boys and girls at school, who are catered for by the Youth Employment Services of the Ministry and of Local Education Authorities. The services of technical officers of the Registers are, however, available to address meetings of Youth Employment Officers, Careers Masters and others directly concerned with careers work.

The need for good advice and for full and up-to-date information to be made available to science and engineering students requires no emphasis. It is remarkable how many graduates are seen by the Register who have given little thought to their future careers until they have taken their degrees, or who say that they would have changed the direction of their university studies if they had been better informed at an earlier stage.

Allocation of Science and Engineering Graduates liable for National Service

One of the functions of the Technical and Scientific Register is concerned with the call-up and deferment of science and engineering graduates liable for National Service. In carrying out this function, representatives of the Register visit all the universities and important technical colleges annually to address and give individual advice to the students concerned. At these meetings are seen not only students studying for a university degree, but men liable for national service who are following full-time courses of study for a recognised professional qualification or diploma at a Technical or Agricultural College.

In the course of their visits to the universities, the Register's representatives bring to the notice of the students opportunities open to graduates in the three Services, pointing out those branches in which scientific or engineering qualifications are most likely to be of value, and those most relevant to the individual's intended post-service career. They also give information about the conditions on which science and engineering graduates can obtain deferment of national service for employment on certain kinds of work.

The Register's interest in the graduate does not cease with his entry into the Forces. Towards the end of his two years' service, he is asked by letter whether he wishes to have the help of the Register in finding employment in civilian life. Many are found to have made their own arrangements but a substantial number accept the offer of assistance.

"The Design of Equipment for Human Use"

A meeting on "The Design of Equipment for Human Use" was held at Cambridge in the Applied Psychology Research Unit of the Medical Research Council on 26th - 28th March last. There were sessions on the military and industrial aspects of work design, on the use and abuse of simulators, on equipment design for training and maintenance, and on automatic data analysis in human research.

There were also 20 practical demonstrations of various aspects of this work, by members of the Applied Psychology Research Unit and also by visiting speakers.

The meeting was attended by 80 representatives, who came from the three Services and the Ministry of Supply, as well as from industrial firms, university departments, and various nationalised industries and Government organisations. A summary of the proceedings will be sent on request to the Applied Psychology Research Unit, 15 Chaucer Road, Cambridge.

Production Engineering Research Association of Great Britain

Quarterly Newsletter to the Institution

Courses for Key Personnel

The success of the five-day courses for key personnel introduced by PERA last year has led to a demand from members for an extension of the Association's educational services. It has, therefore, been decided that permanent training facilities shall be established at Staveley Lodge. The Research Department is now occupying the new building, and the former research laboratories are being converted into a training centre with lecture theatres, study rooms, demonstration bays, etc. Greatly improved lecturing facilities and accommodation will, therefore, be available for all future courses. Practical demonstrations of production techniques will also be facilitated, as equipment is being specially allocated for this purpose. Many members have requested that the general course on improved production techniques should be repeated in 1957, and there has also been a demand for specialised courses on a wide variety of subjects. The course on improved production techniques is, therefore, being held again this year, although some modifications are being made in the light of experience gained during the previous series. Preparations are also being made for five-day courses on metal cutting and pressworking which will include illustrated talks, demonstrations, films, case studies and group discussions.

Research

In the PERA report "Effect of Reaming Conditions on Hole Accuracy and Surface Finish", issued to members last year, it was shown that there are critical values of cutting speed and feed rate above which the accuracy and surface finish of reamed holes deteriorates rapidly. As these critical values are the limiting factors preventing the use of higher cutting speeds and feed rates in reaming operations, it was considered important to determine whether improvements in performance could be achieved by changes in reamer shape. Tests have, therefore, been carried out with high-speed steel machine reamers to determine the effects of reamer shape on the accuracy and surface finish of holes reamed in low carbon steel. Changes in rake and circular land width influenced hole surface finish but did not markedly affect accuracy. The test results also indicated that swarf jamming has an important influence on reamer performance. Other factors investigated included chamfer angle, chamfer relief angle, land relief angle, and flute length. The effect of built-up edge on accuracy and surface finish, the formation of a built-up edge, and factors affecting chip-tool interface friction and temperature are discussed in an appendix to the report.

A report on an investigation to determine the effects of point angle and relief angle on drill performance when drilling steels En 3a and En 10 was issued to members in March. This investigation is one of a series to determine the effect of point shape on drill life when drilling various materials. Marked improvements in drill life occurred with point angles which differ from those normally used in production. The effects of relief angle on drill performances were also investigated.

The fifth and final part of the report "Guide to De-burring of Machined Components" has been issued to member firms. The report describes various types of barrelling equipment and considers their

(concluded on opposite page)

Sir Thomas Hutton *(right)*, Director of the British Productivity Council, with Dr. Galloway, Director of PERA, in the new research block during a recent visit by Sir Thomas to PERA headquarters. The 1,000-ton press in the background is to be used for PERA's investigations into the impact extrusion of steel components.

CORRESPONDENCE

From: **Mr. P. D Collins** (Graduate)

"What is meant by practical training?"

"I do not know" seemed to be the theme taken by Sir Walter Puckey for his address to the meeting of Council recorded in the April Journal.

It may have been his intention to use such a theme just to provoke discussion, but it does raise the wider issue of whether a new award of the kind proposed is either workable or even necessary.

The National Council has decided upon an award which is to be of honours degree level involving a practical training which is almost revolutionary as far as this country is concerned. We are told that this is just not going to be "the mixture as before" but something quite different whilst in the same breath we are told that nobody seems to know how the practical training is going to be organised. Surely, for a scheme supposedly underway this is rather alarming.

If something definite is not decided soon we shall end up with an honours degree coupled to our existing haphazard provisions for practical training — in other words, the mixture precisely as before.

For the present none but the larger industrial concerns will be able to organise anything like the practical training suggested for the award. As for the bulk of our industry, that now well-used phrase, "the small firms must do more", will hardly suffice to get any worthwhile training established if some form of assistance is not forthcoming.

Provisions of practical training is but one of many problems yet to be solved. Only a few large colleges have so far been recognised for the award, and it is debatable whether these will be able to train the number of technologists that we have been told are required to satisfy our immediate needs. Unfortunately, recognition of more colleges is no answer to this problem, as according to Sir Walter's committee many interested colleges show too much evidence of those ugly sisters of technical education — shortage of adequately qualified staff and lack of the necessary accommodation. In fact, we are told that the principals and staffs of some of these colleges are in for a few shocks, which is discouraging as far as their future enthusiasm is concerned.

Even if accommodation is gradually improved, the problem of attracting highly qualified production people into the profession will remain for some time. At one college, recently, a lecturer requested permission to attend a full-time production course of specialist training and was told that, due to the staff shortage, release of any kind was completely out of the question for a number of years to come. Now this is probably not an isolated case and raises the question — if highly qualified people are not coming into the colleges and existing staff cannot be released to become more highly qualified, just how many of our colleges are likely to be recognised for this award in the future?

May I respectfully quote Sir Walter Puckey — "I don't know the answer" — does anyone?

Sir Walter Puckey writes:

I am glad to know of Mr. Collins' interest in this problem, because I spend a good deal of time on it and have indeed prepared a Paper on the subject for the Harrogate Conference.

We must admit that few colleges and indeed companies have so far raised their sights to the standards the National Council is setting, but Mr. Collins will probably agree that standards must be set fairly high so that people may reach up to them.

His final paragraph infers that I know most of the questions, but not the answers. This, up to a point, is true, but the ability to ask the right questions is quite a good one and those of us on the National Council are slowly but surely learning what the answers should be, and are delighted to find a small but increasing group of educationalists and industrial managers willing to provide the sort of answers that we and they think are necessary.

One of the most important things to get clear in one's mind is the worthwhileness of a high level national award such as that now proposed in the Diploma in Technology, and once we convince ourselves that we must raise sights to this level, then in due course we shall find a reasonable number of people willing to tread the difficult path to its door. I hope Mr. Collins will be one of those in the procession.

PERA NEWSLETTER — concluded

suitability for particular applications. Information is also included on barrelling materials such as shipping of natural stone, synthetic abrasives, organic and metallic media and barrelling compounds. It is often assumed that a wide range of components can be de-burred with little variation in barrelling techniques. However, a number of important variables affect the results achieved, and each de-burring operation must be considered separately. Although the most satisfactory barrelling cycle must be determined largely by trial and error, a number of practical examples are given in the report to assist in selecting the most suitable conditions.

Further progress has been made in the Association's survey of high-speed hobbing and an assessment is being made of the effect on hob life of such factors as the number of hob starts, helix angle, and number of teeth in the gear. Studies are also being made of hob wear, and of the effect of slight variations in hob tooth form on hob life.

THE PRINCIPAL OFFICERS, 1957 - 58

The President

The Council of the Institution is pleased to announce that The Right Hon. The Earl of Halsbury, F.R.I.C., F.Inst.P., M.I.Prod.E., has been elected President of the Institution for the year 1957 - 1958.

Lord Halsbury has been since 1949 Managing Director of the National Research Development Corporation, which was set up under the Development of Inventions Act, 1948, mainly to ensure the development and exploitation of inventions resulting from public research.

Born in 1908, Lord Halsbury was educated at Eton, and on leaving went into the City to study chartered accountancy. But he soon turned to science, and as an external student of London University took a B.Sc. degree with first-class honours in chemistry. His first industrial appointment was with Lever Brothers at Port Sunlight.

During the War, at the research laboratories of Firth-Brown, in Sheffield, he worked on the design of special steels for the blades of gas turbines and jet engines. In 1946, he became Research Manager and later Works Manager of the Decca Record Company Limited, where his main research target was the production of gramophone records in unfilled plastic suitable for long playing records with silent surfaces.

Lord Halsbury was a Member of the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research from 1949 - 1954, and is now a member of its Mechanical Engineering Research Board. He has been Chairman of the Science Museum Advisory Council since 1951. He is also a Deputy Chairman of the Parliamentary and Scientific Committee ; Chairman of the National Institute of Industrial Psychology ; Vice-President of the Royal Institute of Philosophy ; and a member of the Court of Governors of the Manchester College of Science and Technology.

He is a Member of Council of the Royal Institute of Chemistry ; a Member of Council of the Royal Society of Arts ; and a Member of the Grand Council of the British Empire Cancer Campaign.

The Chairman of Council

Mr. H. G. Gregory, M.I.Prod.E., the present Chairman of Council, has been re-elected for a further year of office. Mr. Gregory, who is Manager of the Northern Factories of The Fairey Aviation Company Limited, is a Past President of the Manchester Section of the Institution, and has served on the Council for many years. He has also served on several of the Institution's Standing Committees, and has a very considerable experience of its affairs.

He began his industrial life in 1917, as an indentured apprentice with C. A. Vandervell & Company Limited, London, and subsequently held a number of progressively senior positions, his first major appointment being that of Works Manager of Corfield and Buckle Limited, in 1930. He left this firm in 1936 to take a senior executive position with the General Motors Corporation, and in the early years of the War was Director and General Manager of the Burtonwood Repair Depot. He joined The Fairey Aviation Company Limited in 1943.

Mr. Gregory has been a member of the Executive Committee of the Manchester District Engineering Employers' Association for some 11 years, and is also Past Chairman of the Manchester and District Committee of the Foremen and Staff Mutual Benefit Society. In 1955, he was Chairman of the Consortium of Stockport Engineering Employers, which was formed in 1953, and of which he is still a very active member. He has served on the Council of the Stockport Chamber of Commerce since 1948, and was subsequently appointed Chairman of the Membership Committee. He serves also on a Machine Tool Project Advisory Panel, formed in 1955 by The National Research Development Corporation.

The Vice-Chairman of Council

Mr. H. W. Bowen, O.B.E., M.I.Mech.E., M.I.Prod.E., has been re-elected for a further year of office as Vice-Chairman of Council. Mr. Bowen is Managing Director of High Pressure Components Limited.

The Principal Officers take office as from 1st July, 1957.

SIR ALFRED HERBERT, K.B.E.

IT is with the deepest regret that the Council of the Institution records the death, last month, of Sir Alfred Herbert, K.B.E., Honorary Member of the Institution, and President from 1927 to 1929.

From its earliest days, Sir Alfred gave the Institution his wholehearted support and encouragement, and it was in recognition of his generous help and pioneering activities that the "Sir Alfred Herbert Paper" was established, in 1952, as a permanent tribute. It was entirely characteristic of Sir Alfred's outlook that, in giving assent to the association of his name with this Paper, he asked that the subjects chosen should not always lie within the purely technical field. In a letter to Major-General K. C. Appleyard, then President of the Institution, he said: "I feel it is desirable that technical institutions should once in a way depart from their current procedure of hearing lectures connected directly with the practice of their arts, and that their minds should be refreshed by an occasional Paper covering a wider field."

To mark the occasion of his 90th birthday, which he celebrated last year, and in recognition of his outstanding services to the industry, the Machine Tool Trades Association has instituted "The Sir Alfred Herbert Scholarship" to assist engineering students in Coventry to widen their knowledge of machine tool design and manufacture and production methods by visiting engineering works in the United Kingdom or on the Continent. The establishment of this Scholarship was completely in keeping with Sir Alfred's keen interest in the training of young engineers.

The son of a Leicestershire farmer, he served his apprenticeship with Jessop and Sons, and in 1887 became Works Manager of Coles and Matthews, Coventry. He subsequently took over this business in partnership with an old schoolfellow, W. S. Hubbard. Eventually Alfred Herbert became the sole owner of this firm, and in 1894 Alfred Herbert Limited was formed, production being concentrated mainly on tools and machines for the bicycle trade.

During the First World War, Alfred Herbert was appointed Machine Tool Controller, for which services he received a knighthood in 1917.

Sir Alfred was Chairman and sole Governing Director of Alfred Herbert Limited, and President of the Company's subsidiaries in France and Italy. In addition to being a Past President of the Institution of Production Engineers, he was President of the Coventry Engineering Society, an office he first assumed in 1899.

He was widely known for his philanthropic activities. One of his recent gifts was made to enable the City of Coventry to build an Art Gallery and Museum, and many gifts were also made in the name of Lady Herbert.

Sir Alfred was a man of astonishing qualities in many ways; his individuality, strong character and warmheartedness inspired respect and affection throughout the engineering world, and his passing will be keenly felt for many years to come.

NEWS FROM THE MIDLANDS

Annual Dinner

Nearly 200 members (including leading industrialists in the area) attended the Annual Dinner of the Midlands Region, which was held in the Queen's Hotel, Birmingham, on 12th April last.

Among the principal guests were the Lord Mayor of Birmingham; the Lord Mayor of Coventry; Mr. Alick Dick, of the Standard Motor Company; Mr. David Masters, senior test pilot of the Fairey Aviation Company; Mr. E. W. Hancock, M.B.E., President of the Institution; and Mr. H. G. Gregory, Chairman of Council. Brief addresses were given by Mr. Dick, Mr. Masters, Mr. Hancock, Mr. Gregory and the Midlands Region Chairman, Mr. B. G. L. Jackman, in which emphasis was laid on the continuing importance of craftsmanship in producing the equipment for high volume production, and a somewhat critical survey was made of some aspects of British manufacture from the viewpoint of an overseas user.

Tooling Conference

The one-day Conference, organised by the Midlands Region, on "Tooling — Tomorrow's Production" attracted nearly 300 members and visitors to the Botanical Gardens, Edgbaston, Birmingham, on 22nd May last. Those attending enjoyed an exceptionally interesting programme of eight Papers on various aspects of tooling, presented by authorities in their respective fields, as follows:

"Tooling for Precision Presswork" by Mr. J. Galway, Chief Tooling Engineer, C.V.A. Ltd.

"Tooling for Light Alloy Castings" by Mr. A. P. Fenn, Chief Technical Engineer, Birmingham Aluminium Castings.

"Tomorrow's Small Tools" by Mr. F. Sheldon, Technical Sales Manager, Wimet Division, A. C. Wickman Ltd.

"Jigs and Fixtures for Automation" by Mr. C. D. Camwell, Chief Engineer, Birmingham Engineering Department, William Asquith Ltd.

"Tooling for Plastics" by Mr. N. Rolaston, Development Engineer, B.I.P. Tools Ltd.

"Assembly and Welding Fixtures" by Mr. W. H. Telling, Rubery, Owen & Co. Ltd.

"Tooling for Large Presswork" by Mr. J. H. Stephens, Production Engineering Office, Briggs Motor Bodies Ltd.

"Tomorrow's Gauging and Measuring" by Dr. F. H. Rolt, O.B.E., Metrology Consultant, British Engineers Small Tools & Equipment Co. Ltd.

The opening address was given by Mr. Harold Burke, Past Chairman of Council and Joint Managing Director, Concentric Manufacturing Company Limited, and Mr. B. G. L. Jackman, Midlands Region Chairman, presided over the Conference.

Much appreciation was expressed of the excellent arrangements made, for which Mr. T. W. Elkington, Birmingham Section Chairman, was largely responsible.

Enjoying a break for refreshment at the Tooling Conference are *(left to right)* Mr. H. Unsworth (Birmingham Section Committee and Session Chairman); Mr. C. D. Camwell; Mr. B. G. L. Jackman; Mr. E. P. Edwards (Birmingham Section Committee and Session Chairman); and Mr. J. H. Hughes, M.B.E. (Birmingham Section Committee).

FORMATION OF HANDLING GROUP

Members will already have seen, on page 402 of the June issue of the Journal, the announcement of the formation of a Materials Handling Group within the Institution, together with the Terms of Reference and proposals adopted by the Council at their meeting on 25th April last.

The Committee of the Group on Materials Handling are now formulating the details and conditions of membership which, when completed, will be communicated to Region and Sections Committees.

Within the next few weeks Regions and Sections will be asked to appoint a member who will be their representative on the Materials Handling Group. This representative should be a member who is willing to put in a considerable amount of work on behalf of the Group, for it is only by enthusiastic activity in the Sections of the Institution throughout the country that the Materials Handling Group can be successfully organised and so achieve its stated objectives.

Once Region and Section representatives have been appointed, they will be asked to encourage members within their locality to submit themselves for membership of the Group, and to participate in the activities which will be organised by the Materials Handling Group.

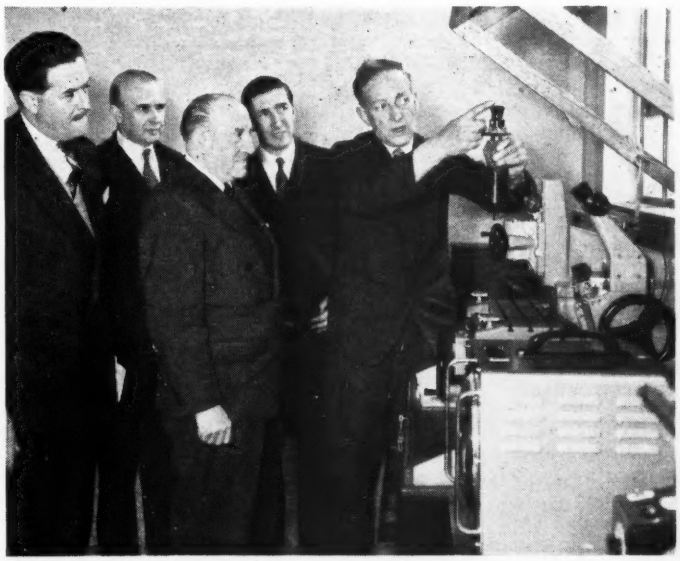
A syllabus for the formal teaching of Materials Handling has been prepared and has been approved by the Education Committee of the Institution. The Materials Handling Group are taking energetic steps to have this syllabus accepted by Technical Colleges and other educational institutions throughout the country.

A. G. HAYEK, M.I.Prod.E.,
Chairman, Materials Handling Group.

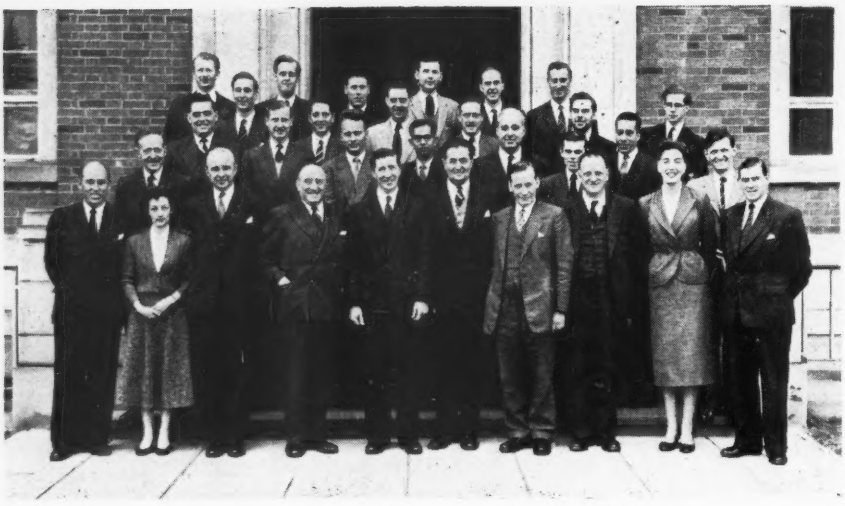
PRESIDENTIAL VISIT TO UNIVERSITY OF BIRMINGHAM

On Wednesday, 8th May last, the President of the Institution, Mr. E. W. Hancock, M.B.E., accompanied by Mr. B. G. L. Jackman, Chairman of the Midlands Region, and Mr. R. N. Marland, Chairman-Elect of the Birmingham Section, paid an official visit to the Department of Engineering Production at the University of Birmingham, at the invitation of Dr. N. A. Dudley, Ph.D., Head of the Department, and Director of the Institute of Engineering Production.

The party arrived at the University at 2.15 p.m., and after being welcomed by Dr. Dudley, spent some time in the Machine Tool Research Laboratory, where a precision grinding research project being



During the party's visit to the Metrology Laboratory, Mr. H. Grisbrook *(extreme right)*, Lecturer in Production Technology, explained the function of the Feeler Microscope, which is an important feature of the S.I.P. Universal Measuring Machine MU214B. Others in the group *(from left)* are Mr. B. G. L. Jackman, Mr. R. N. Marland, Mr. Hancock and Dr. Dudley.



Before leaving the Department, the visitors were photographed with Dr. Dudley and the staff of the Department, and members of the post-graduate course.

carried out there was described to them. After visiting the Film Analysis Laboratory, Mr. Hancock gave a short address to members of the Department. Subsequently the party moved on to the Metrology Laboratory and the Work Study Laboratory, where demonstrations of work in hand had been arranged.

Later in the day, the visitors were taken to the Institute of Engineering Production in Norfolk Road, where they spent some time.

The principal activities of the Department of Engineering Production are (1) the conducting of one-year post-graduate courses leading to the award of M.Sc. in Engineering Production, and in the case of non-graduates, the award of Diploma for Graduate Studies in the Principles of Engineering Production and Management; (2) the carrying out of research projects in the field of engineering production; and (3) the organising of a continuous series of short residential "Productivity Study" courses for senior production engineers and industrial executives. These courses are held at the Institution of Engineering Production.

In expressing their thanks to Dr. Dudley for the opportunity of visiting his Department, and for the excellent arrangements made for them, Mr. Hancock, Mr. Jackman and Mr. Marland said they had been greatly impressed by what they had seen. The information they had gathered and the discussions which had taken place had been of the greatest interest, and they very much hoped that other universities would consider the possibility of developing along similar lines with regard to production engineering.

RESEARCH PUBLICATIONS

The Institution is advised by PERA that Dr. G. Schlesinger's book on "Accuracy in Machine Tools: How to Measure and Maintain It" is now out of print and cannot, therefore, be supplied. The following I.Prod.E. publications are, however, still obtainable from PERA at "Staveley Lodge", Melton Mowbray, Leicestershire.

"Practical Drilling Tests" by D. F. Galloway and I. S. Morton. Price 21s.

"Machine Tool Research and Development" by D. F. Galloway. Price 10s. 6d.

"Surface Finish" by Dr. G. Schlesinger. Price 15s. 6d.

It is also announced that the following PERA research reports are generally released to the public, and may be obtained from Melton Mowbray at the prices stated:

"Packaging of Engineering Equipment." Price 10s.6d.

"Packaging of Engineering Equipment." Price 10s. 6d.

"Hi-Jet System of Cutting Oil Application." Price 7s. 6d.

"Notes on Selection and Use of Soluble Cutting Oils." Price 10s. 6d.

"Drilling Titanium Alloy Ti 150A" (Press reprint). Free.

"Memorandaum — Developments in the Study of Metal and Plastic Slides" (photocopy). Free.

news of members

Lt. Col. A. G. Pirie, Member, has recently retired from military service and has taken up a Production Appointment with Stewarts and Lloyds Limited.

Mr. H. P. Sanderson, Member, has recently taken up a new appointment at I.C.I. Limited, Divisional Headquarters in Birmingham. Mr. Sanderson has been Section Honorary Secretary of the Swansea Section since it was first formed in 1948, as the West Wales Sub-Section.

Mr. F. B. Willmott, Member, Chairman and Managing Director of Francis B. Willmott Ltd., Birmingham, has been elected to the Council of the Birmingham Chamber of Commerce, and also the Central Council of the Economic League.

Mr. T. B. Worth, Member, has been appointed Head of the Production Engineering Department at the College of Technology, Birmingham. The formation of this Department is one of the major developments resulting from the designation of the College as a College of Advanced Technology.

Mr. R. L. Bamford, Associate Member, has recently relinquished his position with the Production Engineering Research Association and has taken up an appointment as Planning Engineer to The Superheater Company Limited, Trafford Park, Manchester.

Mr. F. W. Bevis, Associate Member, has been appointed Lecturer in Production Engineering at the Cardiff College of Technology.

Mr. A. D. Copland, Associate Member, is now Refinery Liaison Engineer of A. & W. Smith & Co. Limited (Tate & Lyle Limited), Glasgow.

Mr. Donald G. Galpin, Associate Member, is now Technical Sales Manager at Ina Needle Bearings Limited, London.

Mr. M. H. Hammill, Associate Member, who has been Director and General Manager of Foster Transformers Limited, South Wimbledon, since 1950 has been appointed Managing Director. Before joining the Foster Company — which is one of the Lancashire Dynamo Group — he was associated for many years with the industrial consultants, Urwick, Orr & Partners.

Mr. F. Hopkinson, Associate Member, leaves Marconi's Wireless Telegraph Company Limited, Chelmsford, where he worked on the Designs Drawing Office Administration, to take up an appointment as Engineering Instructor in charge of the Draughtsman's Training School, in Chelmsford, for the Crompton Parkinson group of Companies. Mr. Hopkinson is Honorary Secretary of the South Essex Section.

Mr R. E. Slaughter, Associate Member, has relinquished his appointment with Messrs. W. E. Sykes Limited, and has taken up a new appointment with Combined Technical Services Limited, of Egham, Surrey, one of the Companies of Production Engineering Management Group.

Mr. R. G. Tench, Associate Member, has relinquished his appointment with The Birmingham Small Arms Company Limited, where he was employed as Production Superintendent, to take up an appointment with Messrs. Fisher & Ludlow Limited, Material Handling Division, Bordesley Works, Birmingham, as Production Manager.

Mr. J. E. Townsend, Associate Member, has been appointed Headmaster of the Secondary Technical School in Cyprus, and will be leaving the United Kingdom very shortly.

Mr. D. A. Bowman, Graduate, has recently been appointed to the Technical Staff of the Scottish Council (Development and Industry).

Mr. J. Davies, Graduate, has taken up an appointment with the Central Electricity Authority, South Eastern Division, as Third Assistant Engineer (Production), at Divisional Headquarters, Kingston.

Mr. B. E. Jackson, Graduate, has now taken up a position as a Methods Engineer with the Northern Electric Co. Limited, Montreal, Canada.

Mr. G. F. Lloyd, Graduate, has relinquished his position as Works Manager of William Gardner & Sons (Glos.) Limited, and has taken up an appointment with Urwick, Orr & Partners Limited, London, Management Consultants, as a resident consultant with the engineering division.

Mr. N. Swaminathan, Graduate, has taken up an appointment with Metropolitan-Vickers Electrical Limited, Manchester, as an Engineer-Trainee of Heavy-Electricals Project of India. Mr. Swaminathan intends to remain in England for about three years.

Hazleton Memorial Library

REVIEWS & ADDITIONS

REVIEWS

"Man and Automation" by L. Landon Goodman. *A Pelican Book published by Penguin Books Ltd.* 3s. 6d.

This book is in the nature of a review of automation and its possible impact on mankind. It was, one would hazard, written for the general public ; but since there is a wealth of well documented references and a considerable index, it should be of value to those who are interested in automation from the practical aspect. There are eight pages of photographs and a number of diagrams and tables. Ninety-three pages are devoted to technical aspects and 146 to social, economic and other arguments.

In the introduction the author quotes a number of definitions of that elusive word "automation", and finally gives a composite one of his own which, while being an advance on the others, still lacks the simplicity of a satisfactory statement of the meaning.

In a "general outline" the author follows through with descriptions of mechanical handling, processing, sensing, control and production techniques, to the integration of processing and handling.

The machine tool section could, with advantage, have been more fully considered. On the other hand, the electronic control of machine tools is dealt with very adequately in a book which is not primarily addressed to the engineer. Data processing is also considered at some length. Three chapters entitled "Automation in Commerce", "Automation in Industry", and "Some Other Effects of Automation" are good reportage. The machine tool industry is somewhat roughly handled in Chapter 7.

In the section devoted to social questions there is sympathetic consideration of reduundancy coupled with a statement that automation will not come suddenly . . . . "Many years of planning are necessary ; much experience has to be obtained. By present standards immense amounts of technological knowledge must be available to, and in, management. Much capital is needed for new plant and markets have to be conditioned and available for the goods produced. All these are factors which put a brake, a heavy brake, on the development of automation."

In order to counteract the fears that have been generated by prejudiced or ill-informed persons, the author advises explanation to workpeople about the purpose and effects of automation. "Nothing", he says, "should be left to chance, 'the grape-vine' or 'the-man-who-knows'." He stresses the fact that the written word is not enough and that "personal contact of the right type is needed to spread information and to discuss these matters".

By far the largest section of the book is devoted to "Economic and Social Implications of Automation" and in this quite considerable review the "dismal science" has the lion's share of attention. *Inter alia*, the author deals with the urgent problem of the higher wage demands likely to be made by personnel engaged in the automated industries — a problem made more than usually difficult by the fact that most firms will only be automated in part, e.g. the present level of automation in the motor industry (the most advanced in this technique) is quoted as 6% of the plant employed. He says: "It is difficult to see an easy solution. Possibly the best answer is that the level of wages should not be allowed to rise unduly in the automated industries, and that the main benefits of increased production should be spread over the whole community in the form of lower prices. Any sums due to the workers over a certain figure might be paid into trust funds for severance payments on redundancy, pension funds and improved social facilities. The guaranteed annual wage fund . . . is an excellent practical example of a way of keeping wage rates reasonably level and reducing inflationary tendencies."

The quotations given here should indicate the wide range and scope of the book which is a useful addition to the growing library of works on automation.

"Friction and Lubrication" by F. P. Bowden and D. Tabor. *London, Methuen ; New York, Wiley,* 1956. 150 *pages. Illustrated. Diagrams.* 10s. 6d.

Bowden and Tabor are well-known to engineers for their work on friction. They have now condensed their major work, "Friction and Lubrication of Solids" (Clarendon Press, 1954) into a small volume of 140 pages. It contains a precis, and an introduction, which starts right at the beginning of the story of friction, and leaves no doubt as to what the authors are talking about. This clearness of description prevails throughout the book, both in explanation and in the logical sequence of the chapters.

"The Nature of Surface" is followed by chapters on adhesion, oxide films, and surface temperature of sliding. Non-metal friction is then described in detail.

People who wish to appreciate the subject of friction without studying it in detail will find this book just what they require. Others will find that sufficient information is given to whet their appetite for more detailed studies. I thoroughly recommend this book. R.E.M.

ADDITIONS

Starr, C. H. **"The Specification of Management of Materials in Industry."** *London, Thames and Hudson,* 1957. XII. 194 *pages. Diagrams.* 23*cm.* 21s.

The author is of the opinion that managers and engineers pay insufficient attention to "materials application engineering", materials specification, and to materials standardisation. He advocates the establishment in each firm of a central materials department, and gives details of its duties, its staff, and its office organisation. The neglected art of writing specifications is discussed, and numerous examples given ; and the essential qualities of a numbering system for materials specifications are given.

Stibitz, George R. and Larrivee, Jules A. **"Mathematics and Computers."** *New York, London, etc., McGraw-Hill Book Co. Inc.,* 1957. VI. 228 *pages. Illustrated. Diagrams.* 24*cm.* £1 17s. 6d.

This book differs from most "semi-popular" books on computing and computers, in that it deals almost exclusively with the mathematical bases of computing. The mathematics in the first chapters will be familiar to mathematicians, and probably to most engineers. Later chapters deal with numerical analysis, digital computer components, logical design of digital computers, analogue computers and simulators, computing with random numbers, computer errors, and computers at work. This last chapter is probably the only one which can be fully appreciated by people with no knowledge of mathematics beyond school level, but even these, with a little perseverance, should be able to learn something from the rest of the book.

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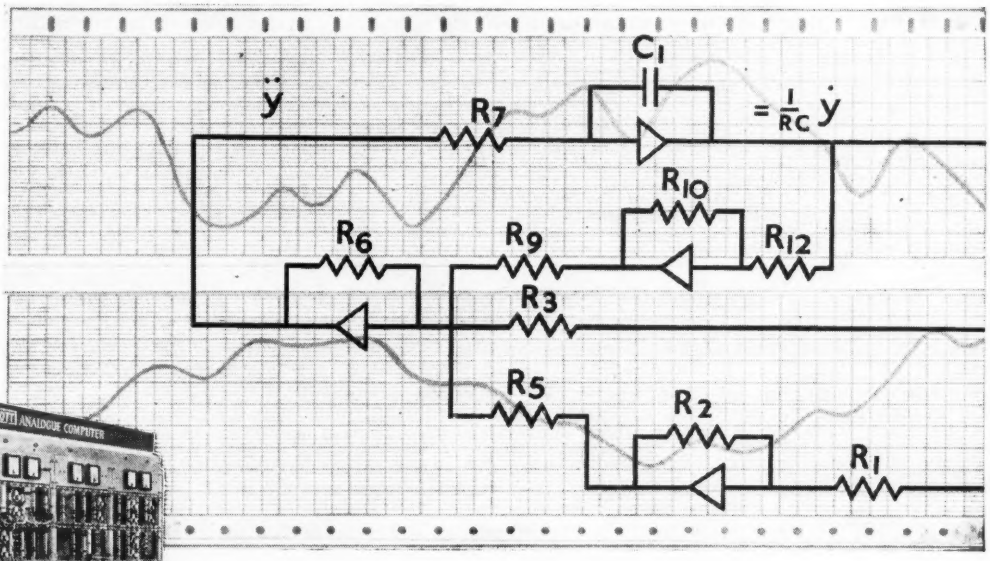

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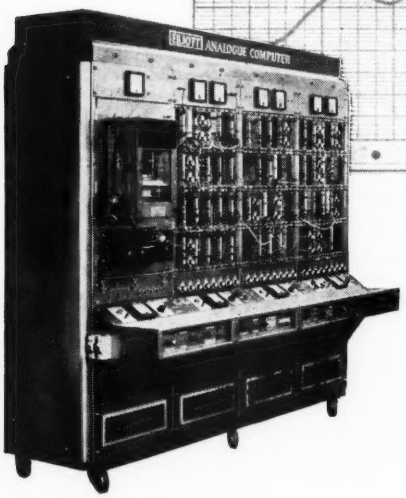

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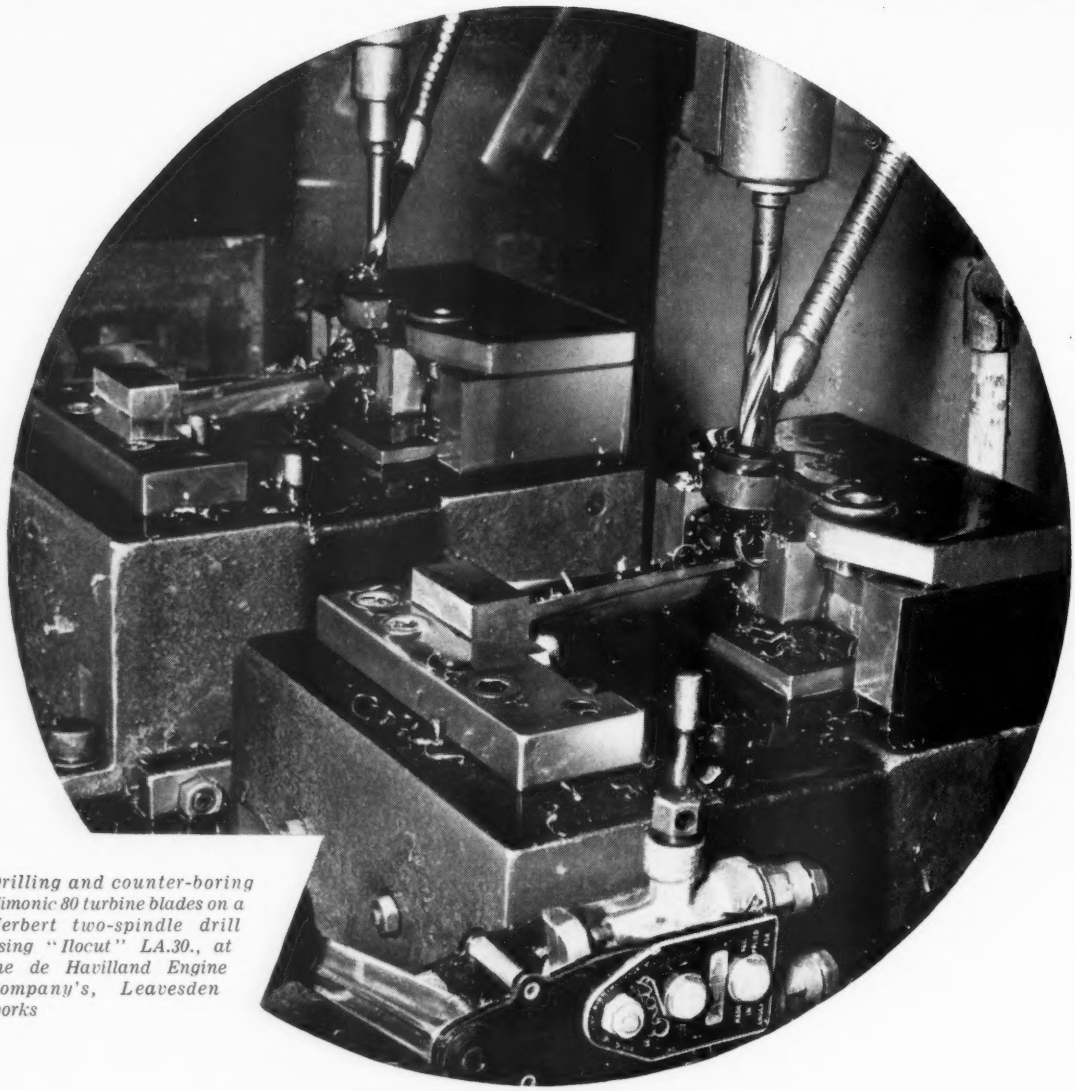

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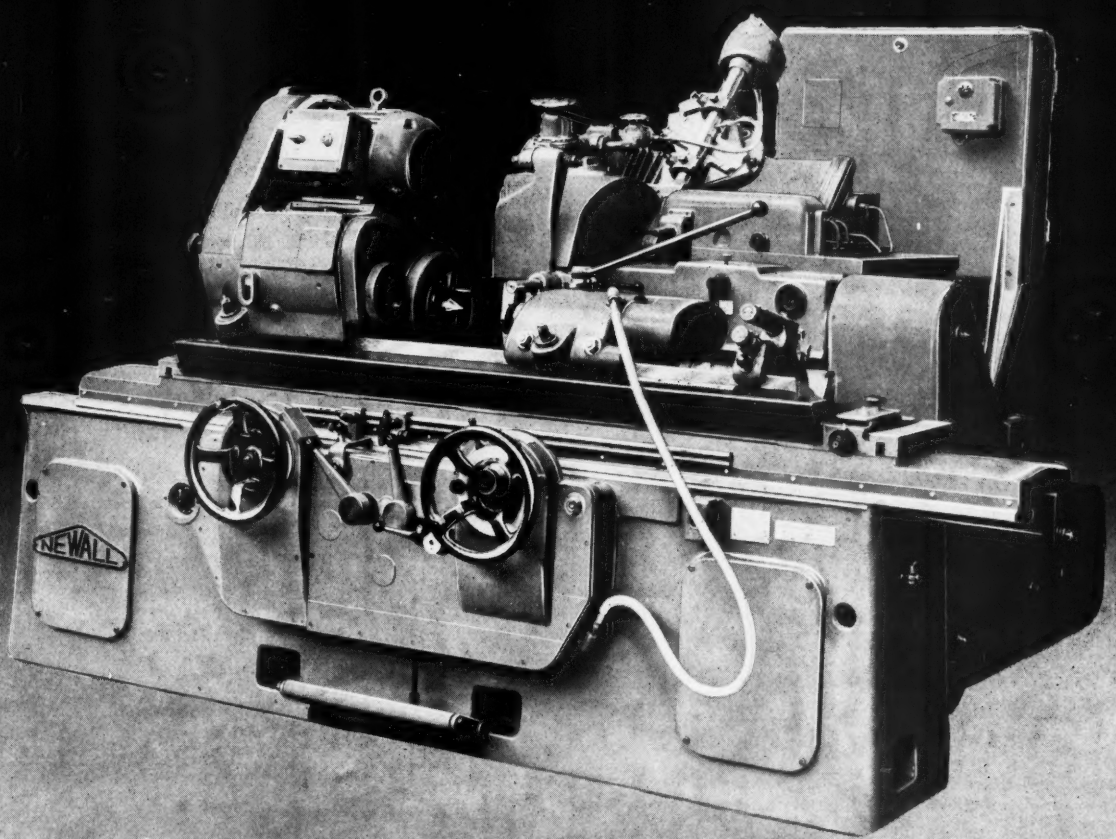

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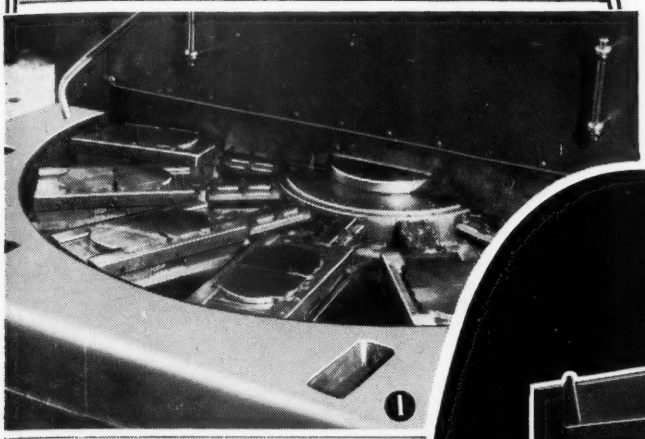

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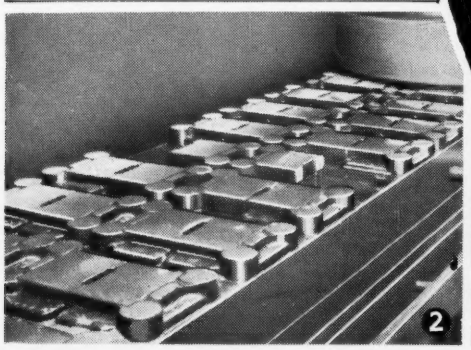
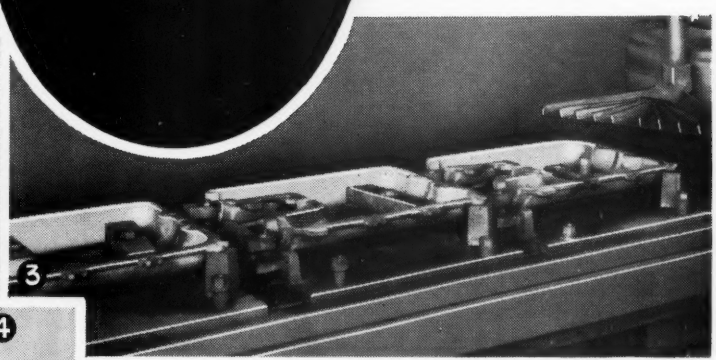
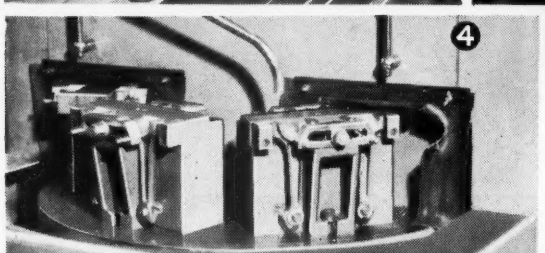
(Below) Removing .30″ stock from either side a connecting rod at rates up to 180 of each per hour.







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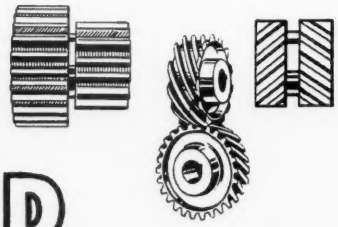

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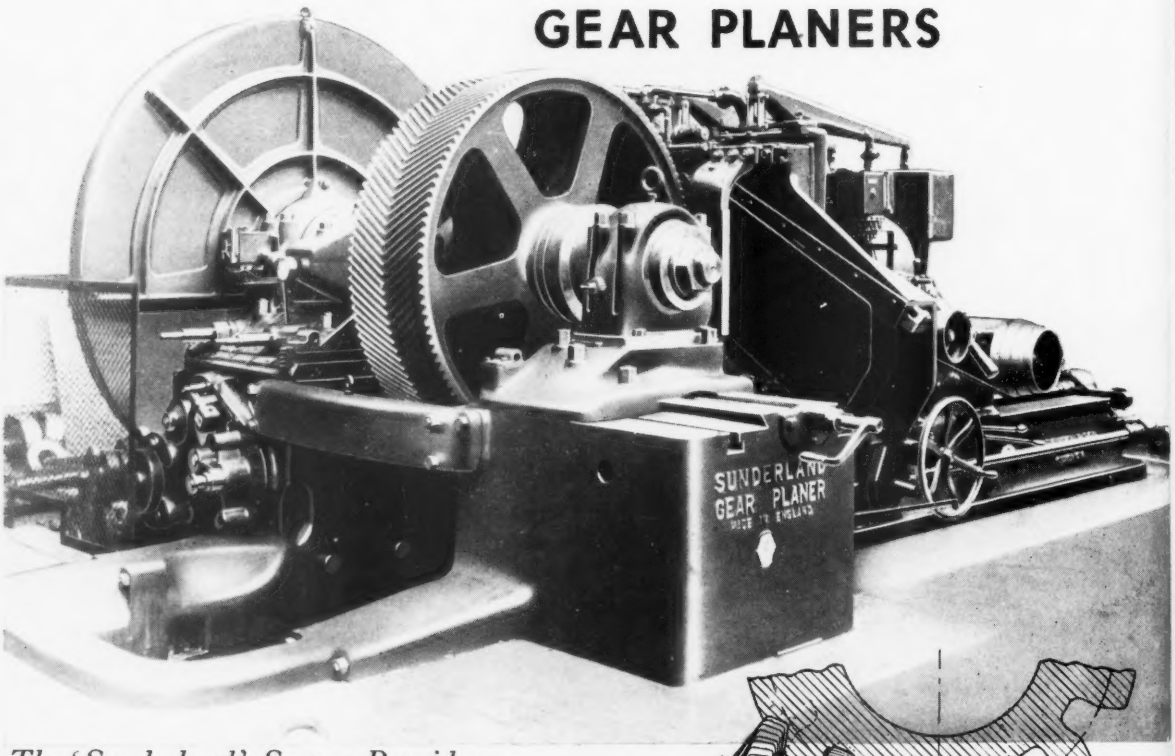

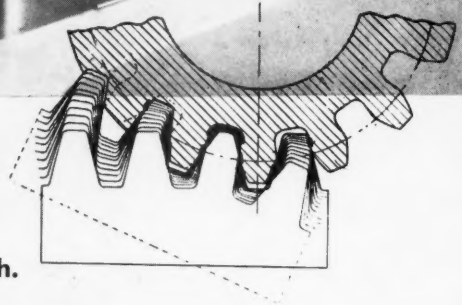

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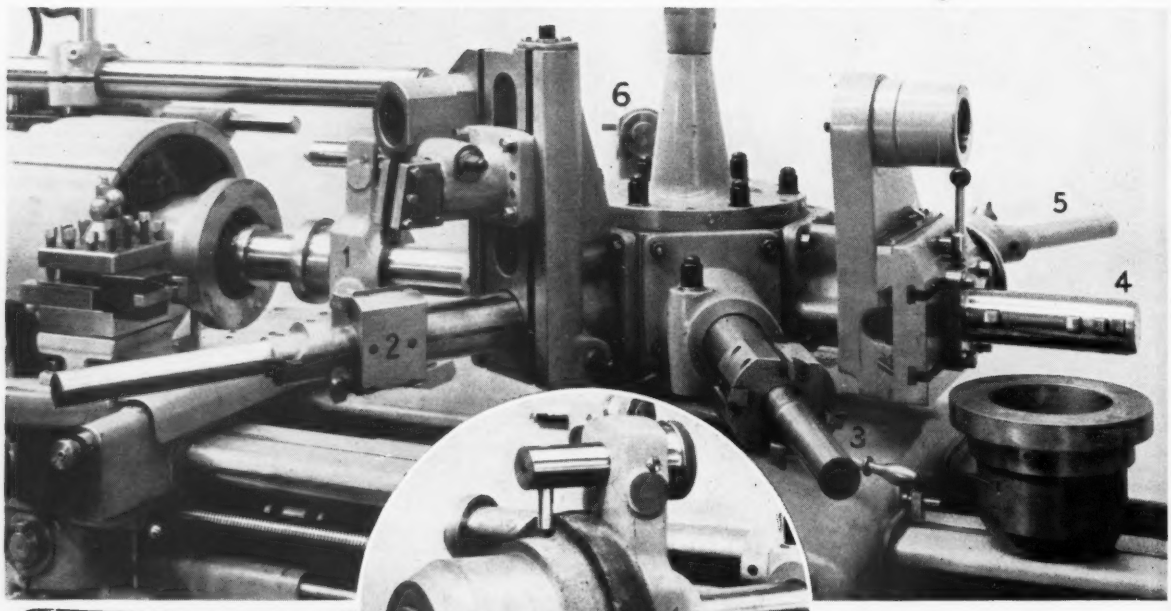

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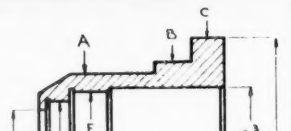
No. 8 TURRET LATHE

FITTED WITH 15in TUDOR 3-JAW CHUCK

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on A (using Loading Attachment) -	1	—	—	—	—
Rough Face and Rough Turn C (1st cut)	—	Front 1	85	235	48
2. Rough Bore $6\frac{3}{16}$ and $4\frac{9}{16}$ and Rough	—	—			
Turn C - - - - - - - - -	2	—	85	230	70
3. Rough Bore D and E - - - - -	3	—	85	133	70
Rough Turn B and Face Back of Flange	—	Front 2	85	225	70
4. Undercut and Chamfer Bores (Recessing	—	—			
Toolholder) - - - - - - - -	4	—	85	133	Hand
Microbore D, E and $6\frac{3}{16}$ dias. - -	5	—	175	285	98
5. Finish Turn C - - - - - -	—	Front 3	175	465	70
Finish Double Face Flange - - -	—	Front 4	175	465	70
6. Remove Part from Chuck (using Un-	—	—			
loading Attachment) - - - - -	6	—	—	—	—



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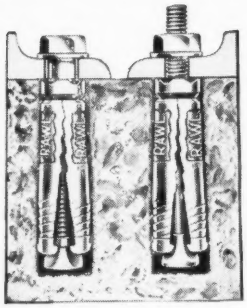

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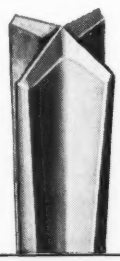

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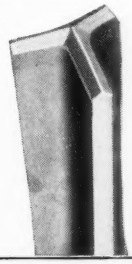

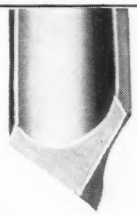

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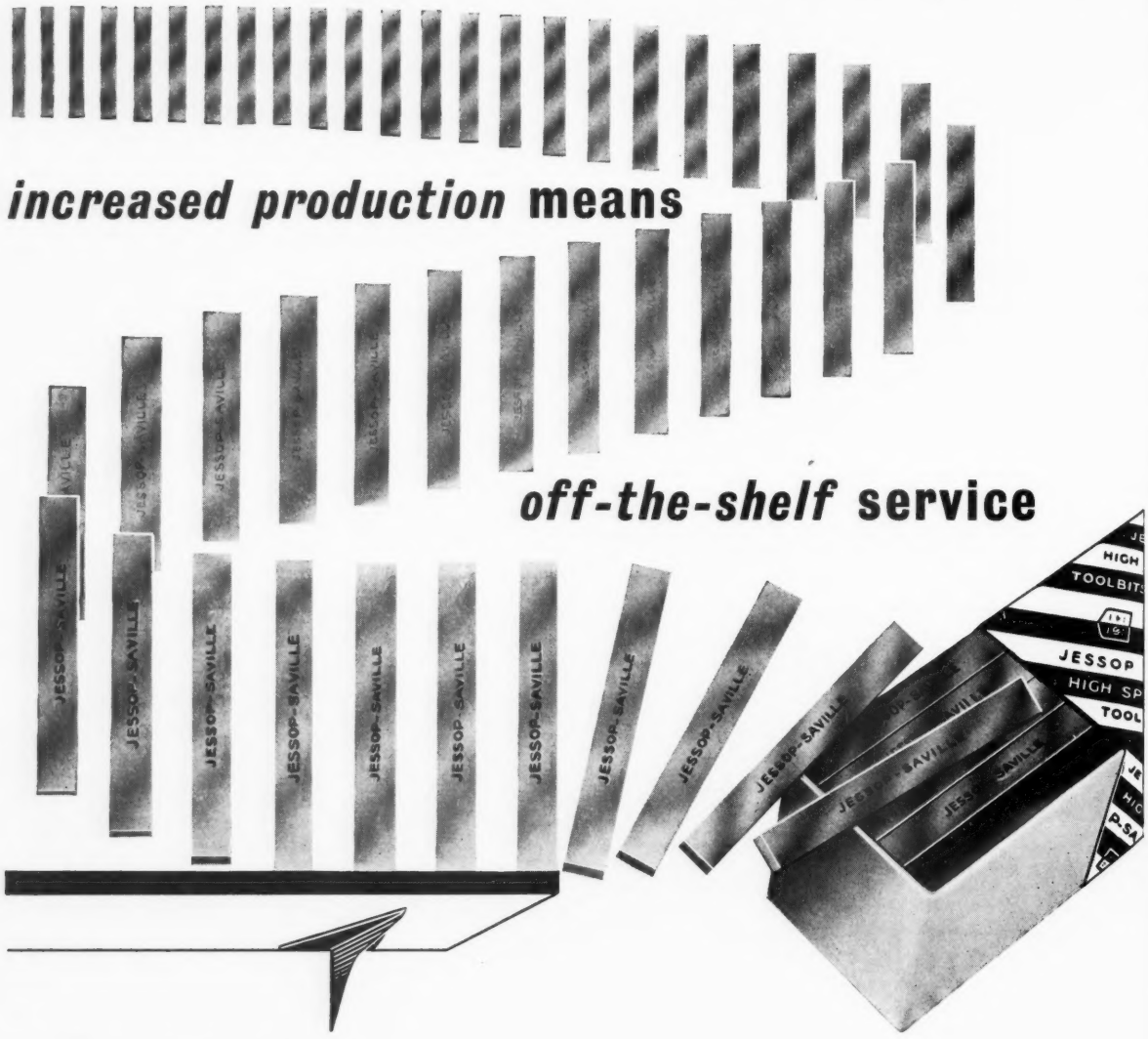

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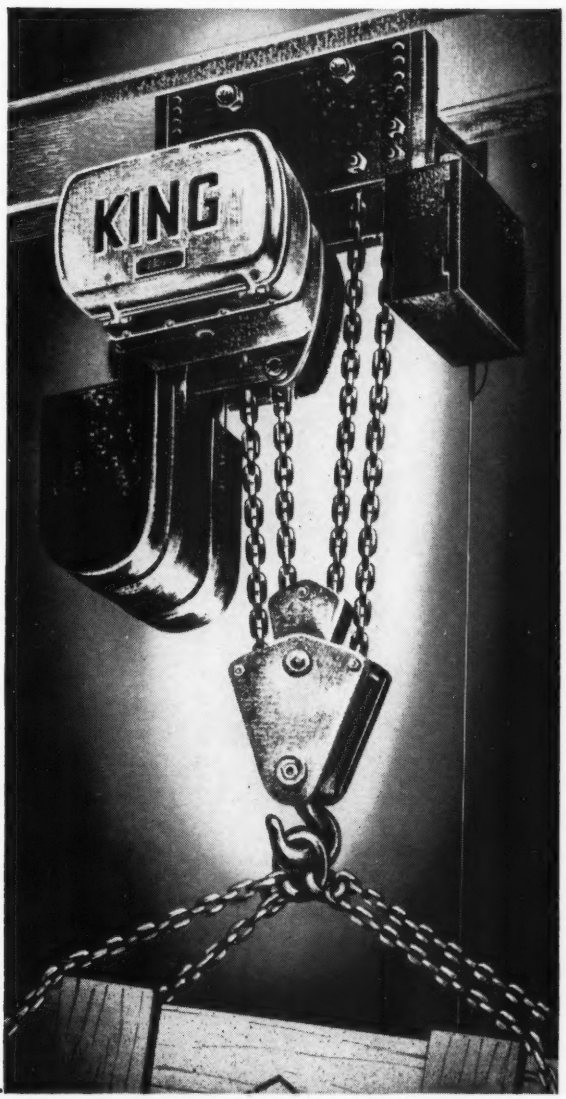

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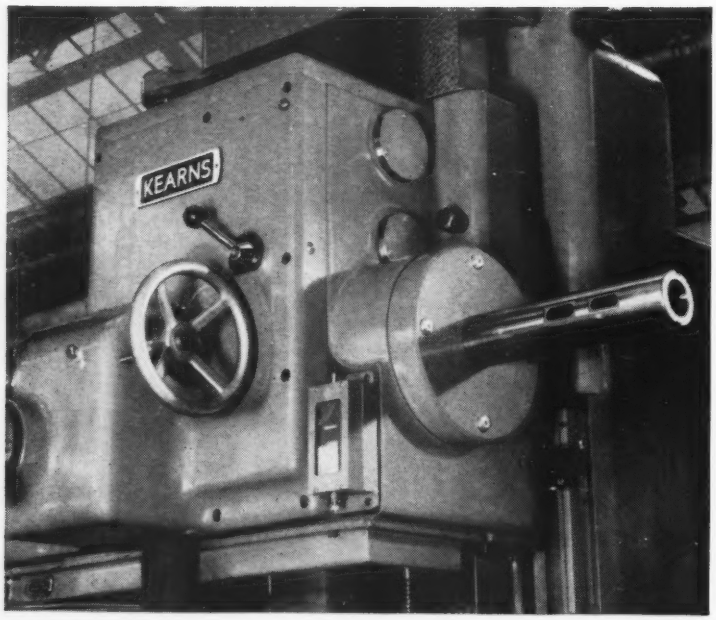

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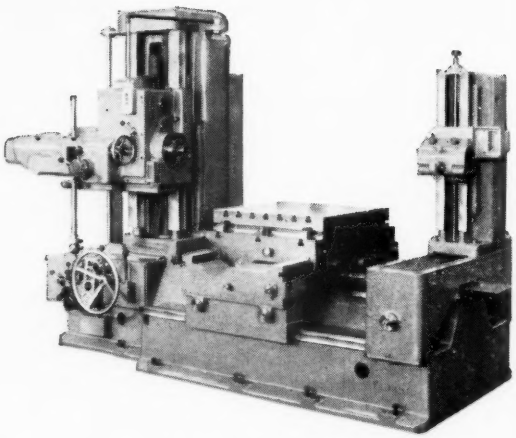

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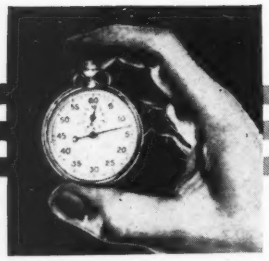

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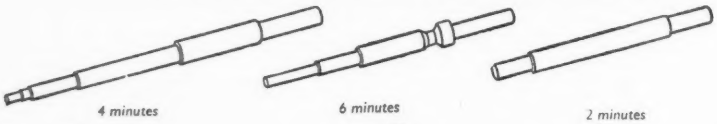

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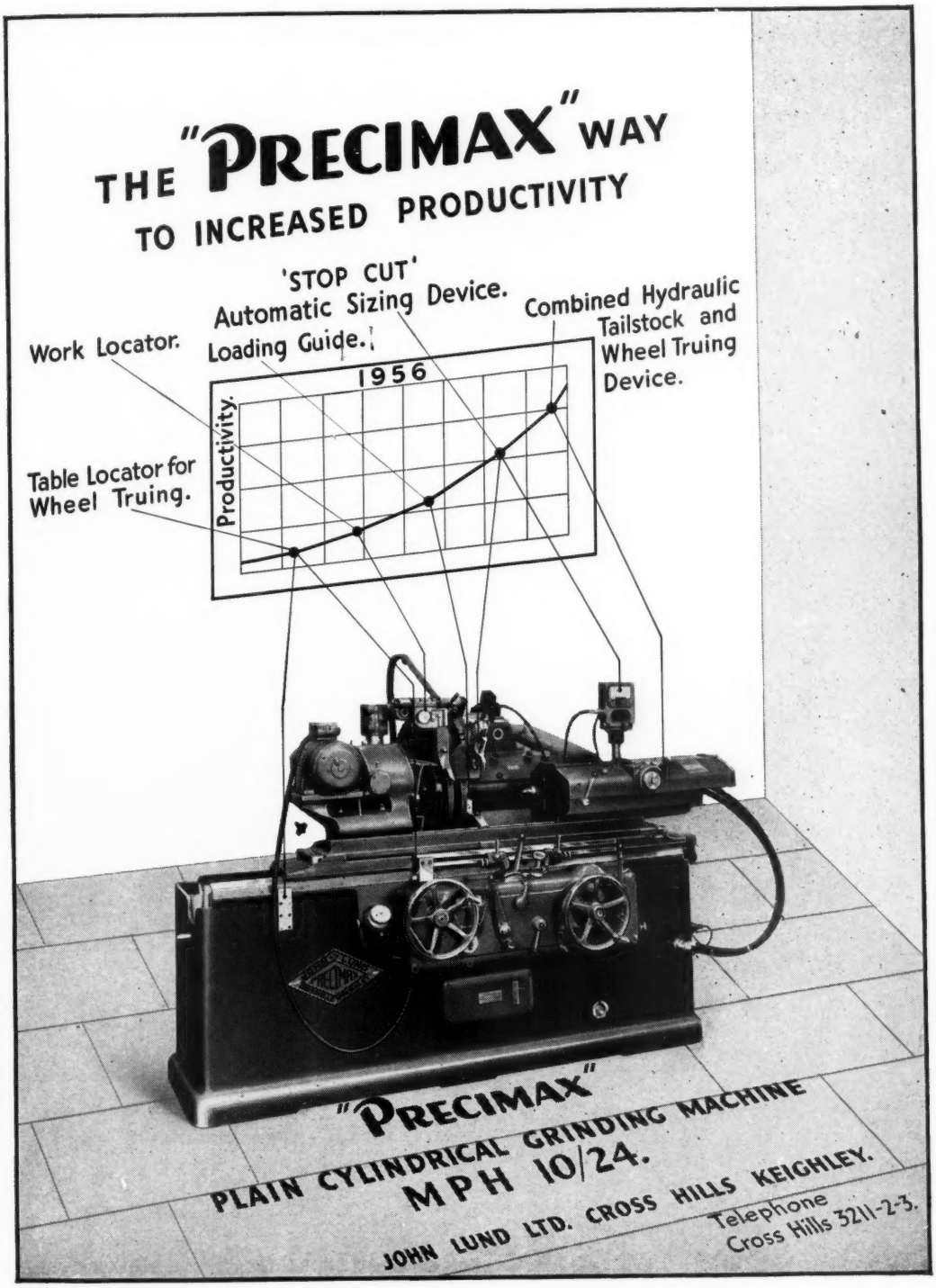
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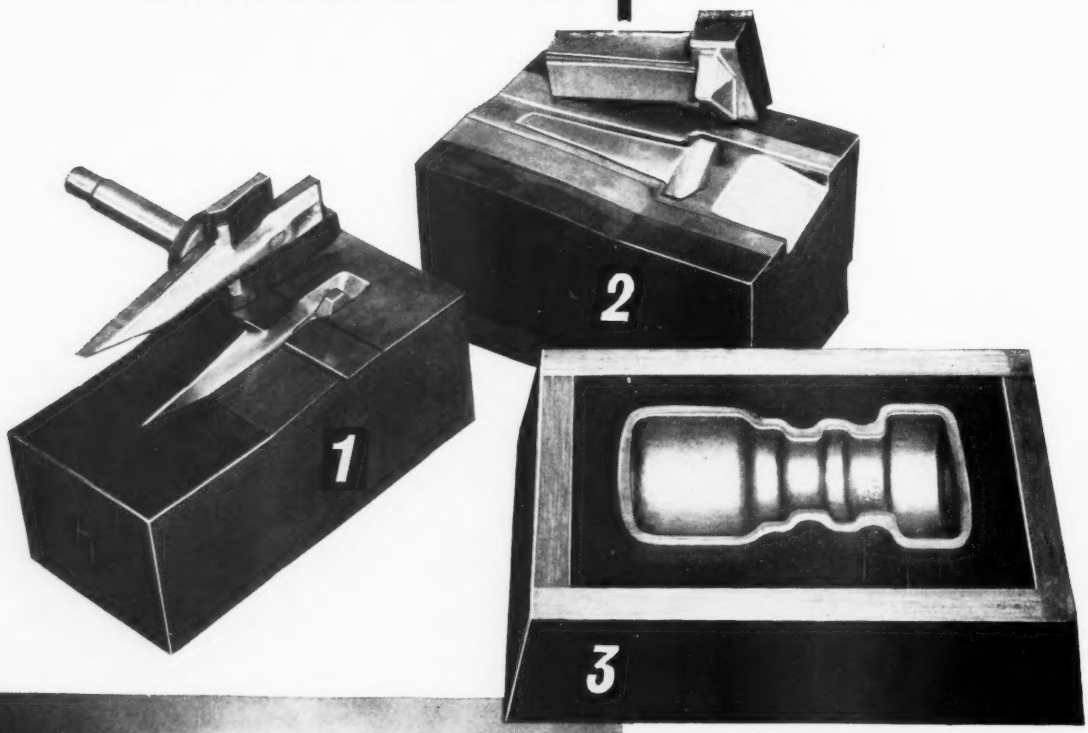

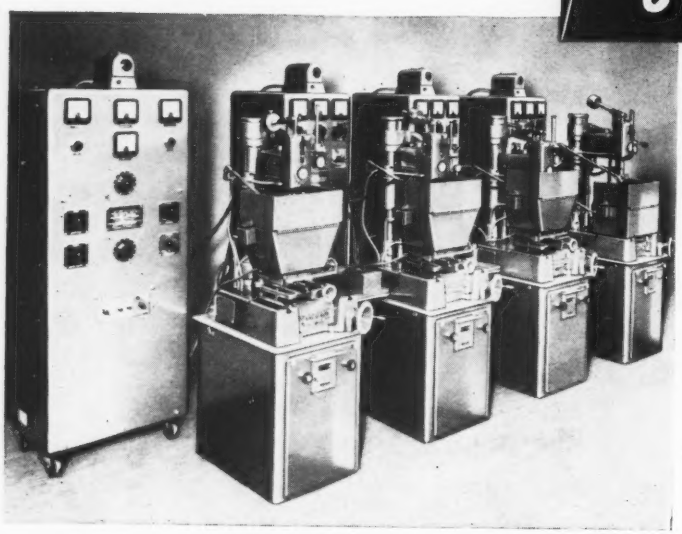

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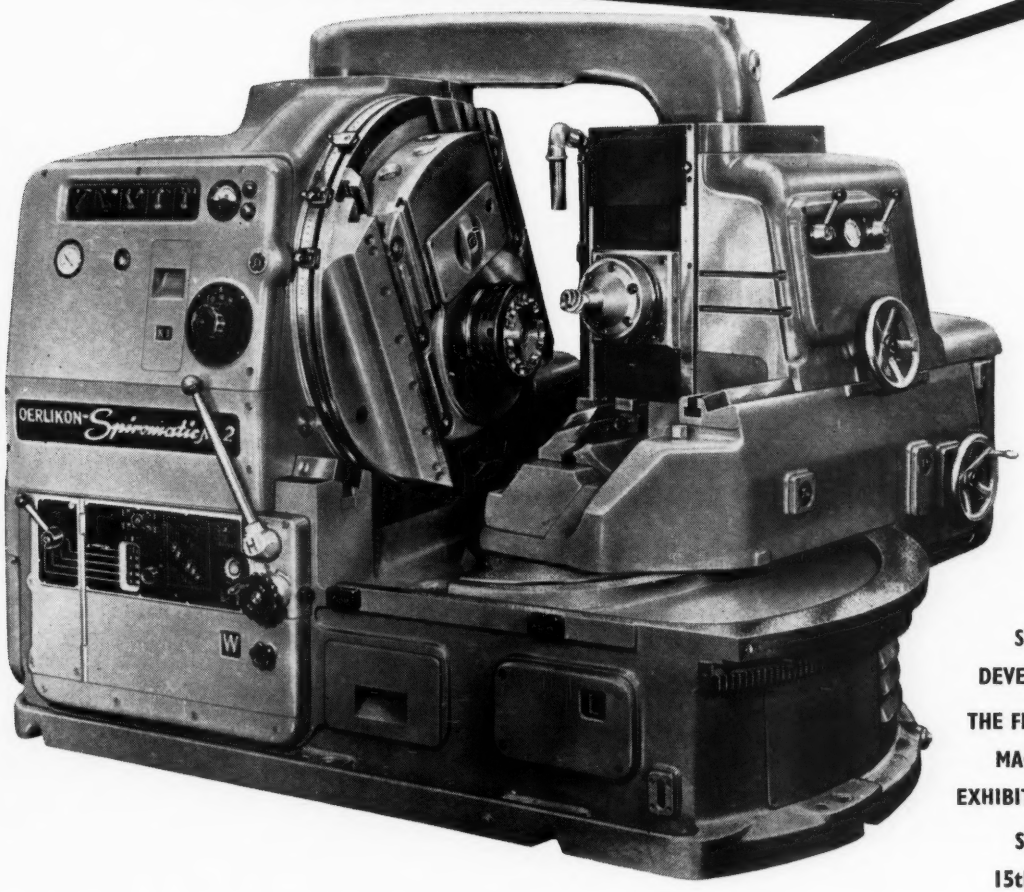

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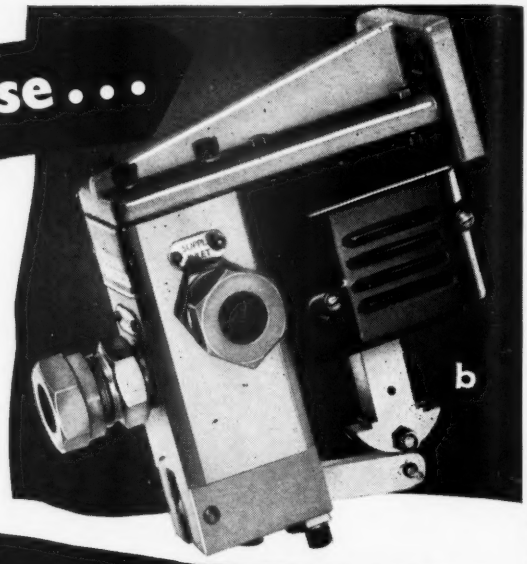

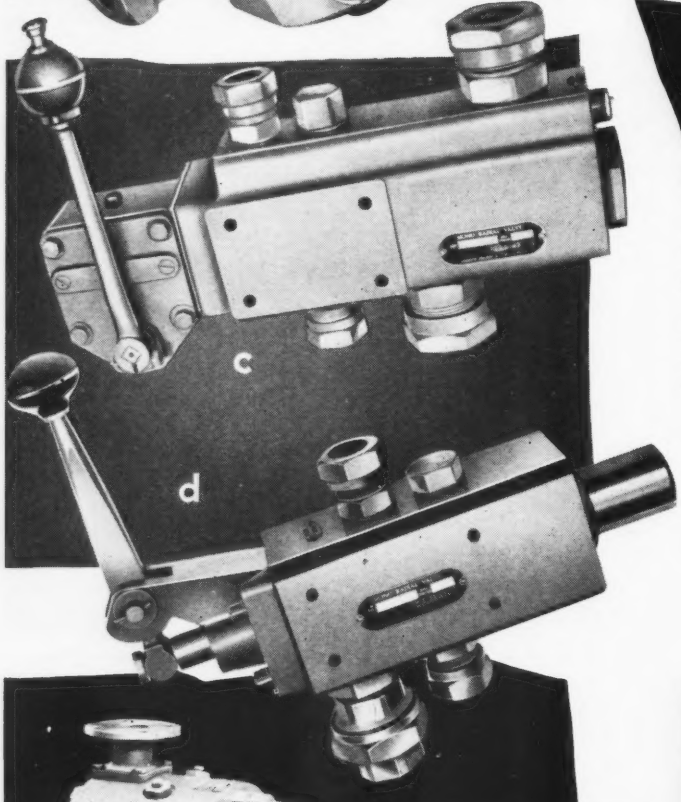

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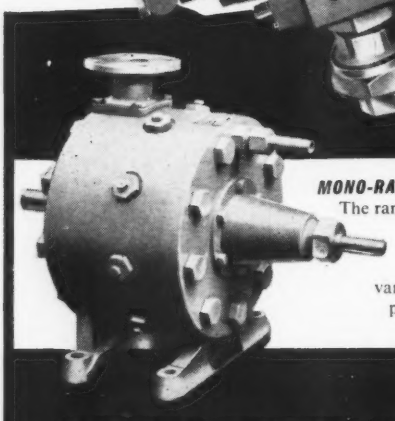

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P.5788

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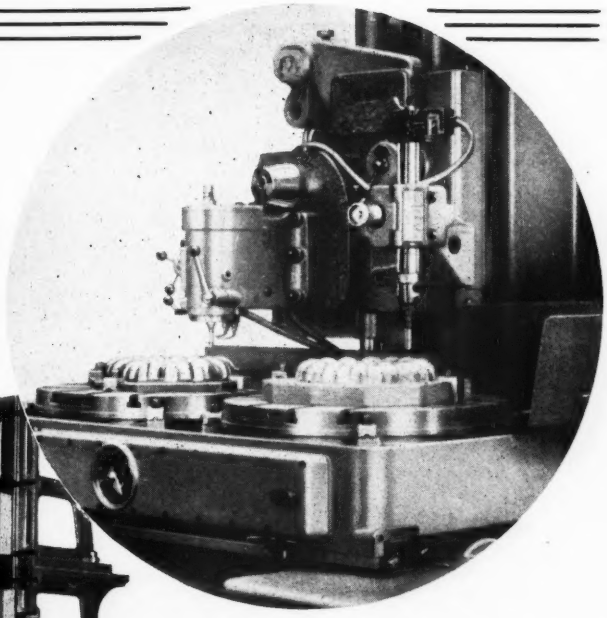
for HORIZONTAL...
VERTICAL...
MIRROR...
CIRCULAR...
SEGMENT COPYING



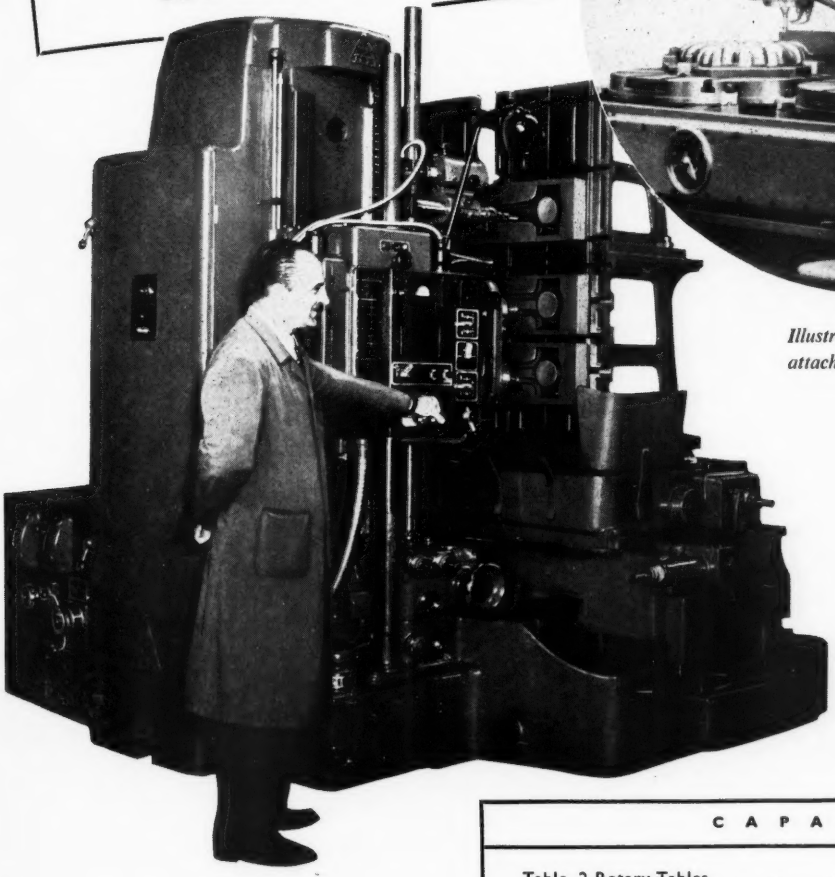


Illustration shows machine copying with vertical attachment fitted, and using the two rotary tables

MODEL FKO8c
TWO MILLING SPINDLES

Arranged with two angle plates for simultaneous reproduction of two components

SEE THIS MACHINE AT OUR SHOWROOMS

CAPACITY	
Table, 2 Rotary Tables	27½in. dia.
Longitudinal Table Traverse (automatic)	39⅜in.
Transverse movement of slide	15¾in.
Vertical travel of spindle head	31½in.
Spindle Speeds (8)	70 to 800 or 335 to 3,600 r.p.m.
Feeds (8)	
Longitudinal Table Feed (per min.)	25/32in. to 8⅞in.
Spindle Vertical Feed (per min.)	17/32in. to 5⅞in.
Net weight approx.	9½ tons

☛ **Our showrooms are only a few minutes from London Airport.**

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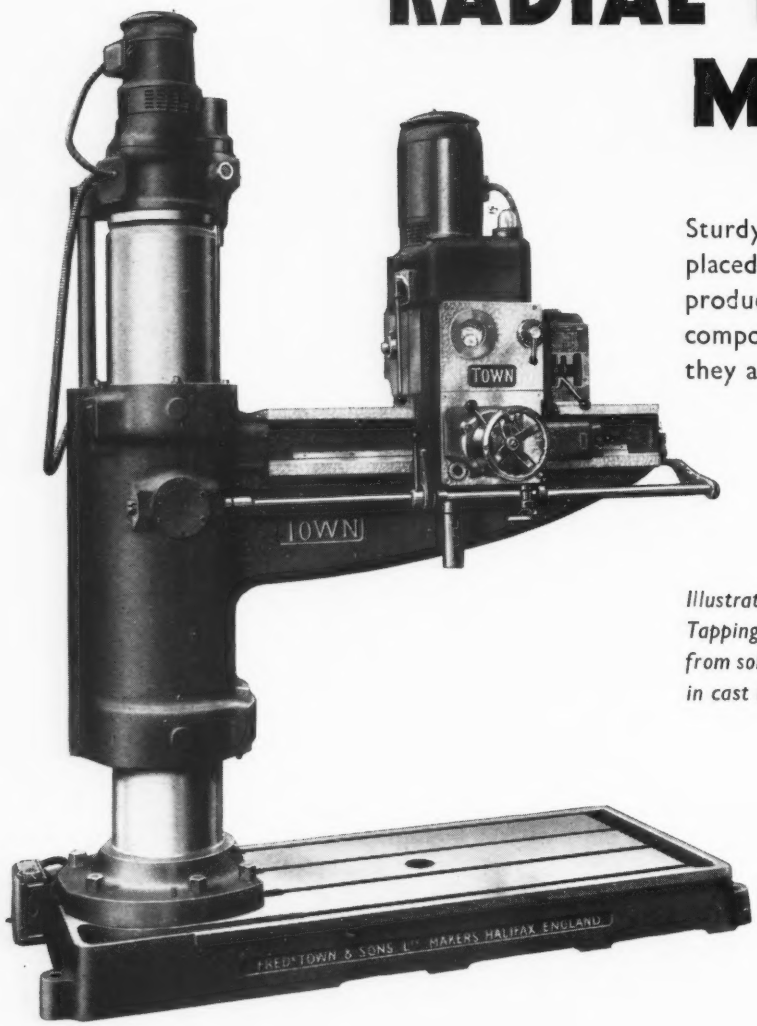
TOWN

RADIAL DRILLING MACHINES



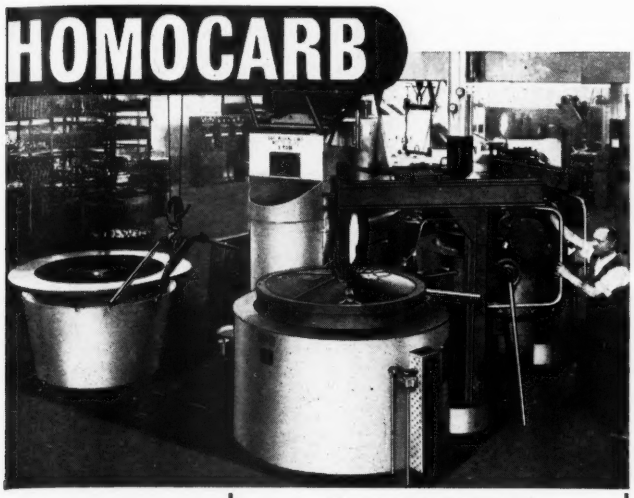
Sturdy simple design, conveniently placed controls and maximum rates of production on the widest range of components—a few of the reasons why they are used all over the world.

Illustrated: Town 5ft. A.E.4 Radial Drilling, Boring, Tapping and Studding Machine. Drilling capacity from solid 2⅛in. diameter in steel and 3in. diameter in cast iron. Tapping 1¼in. Whitworth in steel.

FREDERICK TOWN & SONS LTD

HALIFAX · YORKS

T.2



Electrically heated
Gas Carburising Furnaces

The original BRITISH TIMKIN installation

We have now been honoured by instructions to supply the Gas Carburising equipment for their new Daventry Factory.

British Timken Ltd. have had long experience of the Homocarb method of electrically heated, drip feed, gas carburising and the decision to equip the new factory with these furnaces is surely the greatest possible tribute to efficiency.

Three of these furnaces will be the new revolutionary, Microcarb Control type which provide

Positive instrument Control of Carbon

The carbon you set on your instrument determines automatically the surface carbon of the work being treated.

This is the greatest basic advancement in the science of heat treatment, so send for the special catalogue now.

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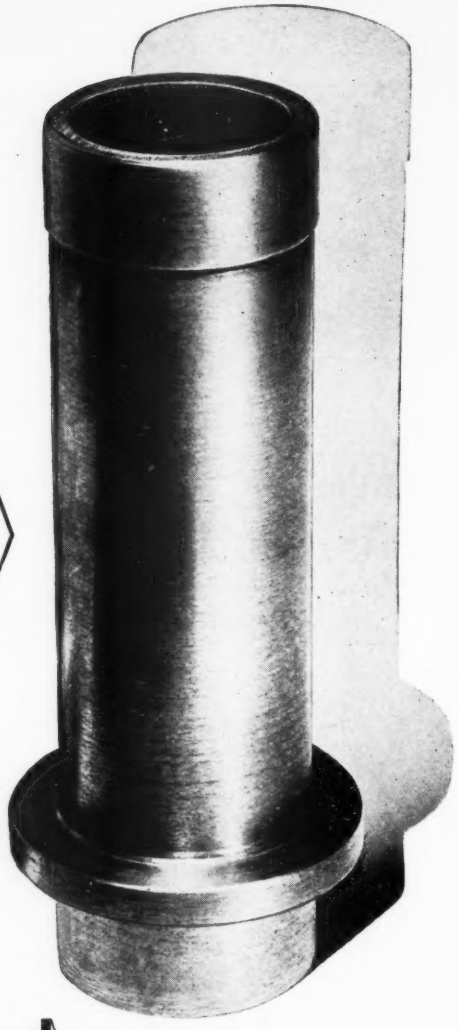
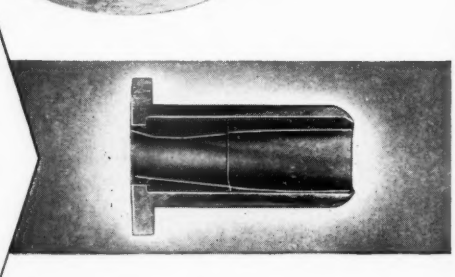


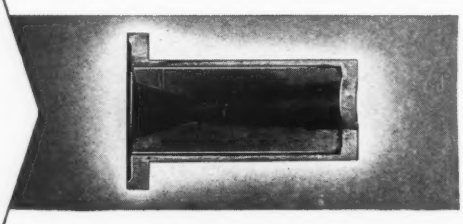
Seeing is believing !

The photographs below show the results of a comparative test made between a Tungsten Carbide Nozzle and a Carbon Tetra Boride Nozzle used with carborundum shot at an air pressure of 75-100 lbs per sq. inch.

The $\frac{3}{16}$" bore Tungsten Carbide Nozzle was worn to this condition in *two* weeks.



The $\frac{3}{16}$" bore Carbon Tetra Boride Nozzle with tapered lead-in was worn to this condition in *eight* weeks.



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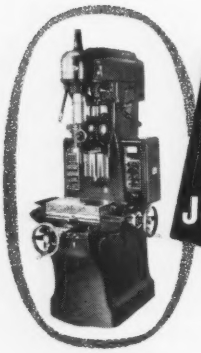
MOORE-CATMUR



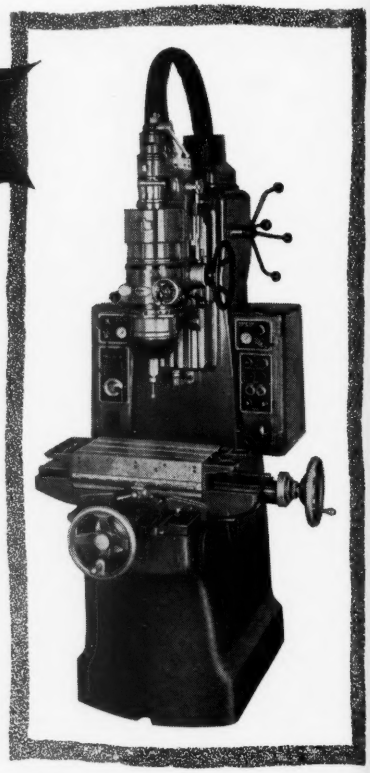
and the MOORE CATMUR JIG Borer

the ultimate in

JIG GRINDING

We proudly present the first British built Moore-Catmur Jig Grinder. This fine machine cuts time by 25%, accurately locating and grinding holes and contours.

Fast accurate grinding of any contour, regular or irregular, is simple with the Moore-Catmur Jig Grinder. Particularly valuable for form grinding of die sections.



Let us forward further details.

Supplied with infinite range of grinding speeds from 12,000 to 60,000 r.p.m. Table area 10" × 19".

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Rainbow

PATENT CALIPER GAUGE MODEL 52

Each month one of the seven main advantages of this fine precision instrument will be described.

- Many different gauging positions can be obtained.
- The anvils are set so that they do not roll.
- All shearing action is eliminated.
- ★● Particularly suitable for gauging shouldered work.
- Can be used for either left or right hand threads.
- Particularly suitable for the gauging of acme forms of thread.
- Can be supplied for "GO" only, or "NOT GO" only, or both "GO" & "NOT GO" combined.

NOTE THIS MONTH'S IMPORTANT FEATURE

★ **PARTICULARLY SUITABLE for GAUGING SHOULDERED WORK**

For protection purposes, the anvils are set back slightly from the jaws so that the necessity for guards is eliminated, consequently this model is very suitable for gauging shouldered work with ease and accuracy.

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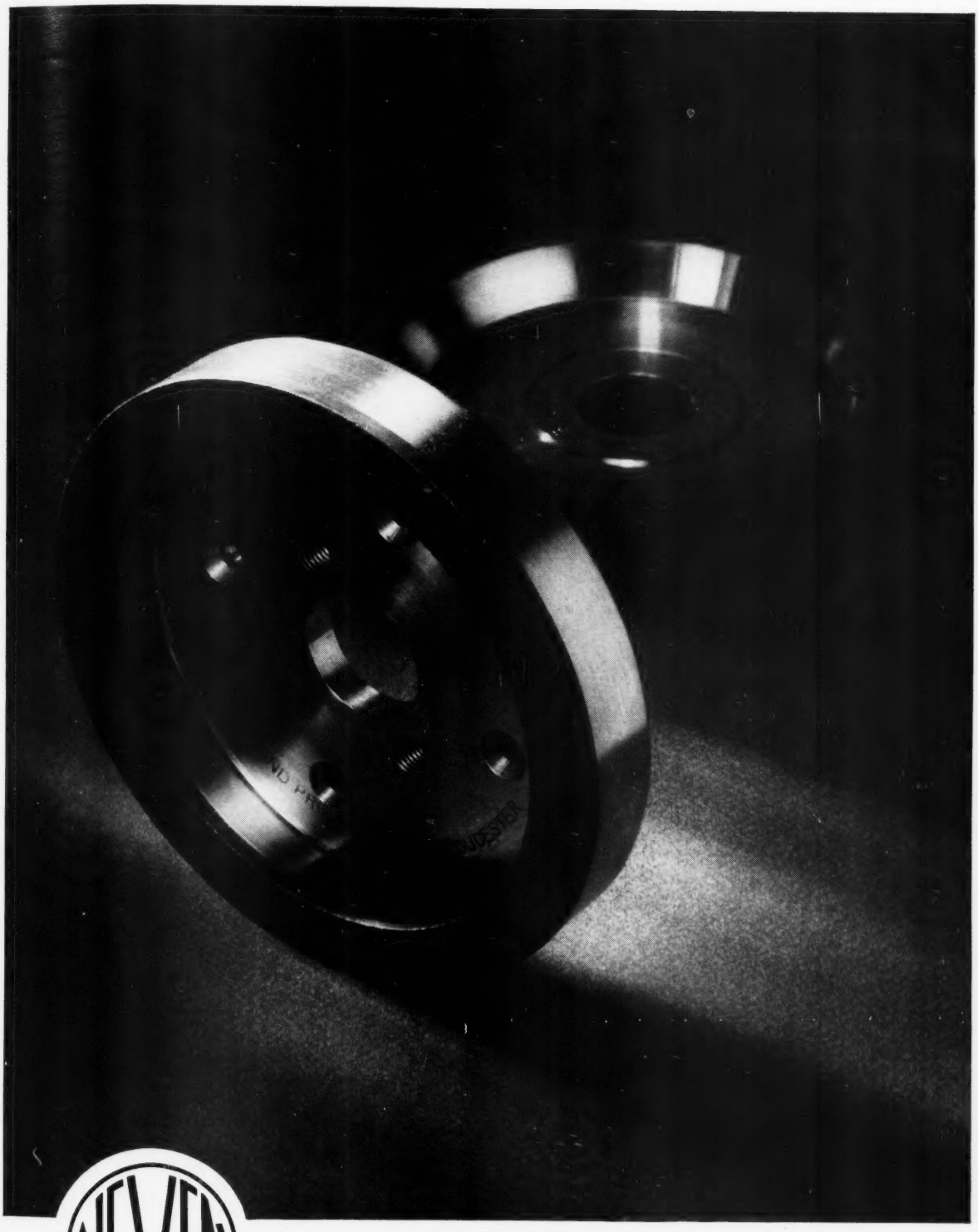

NEVEN

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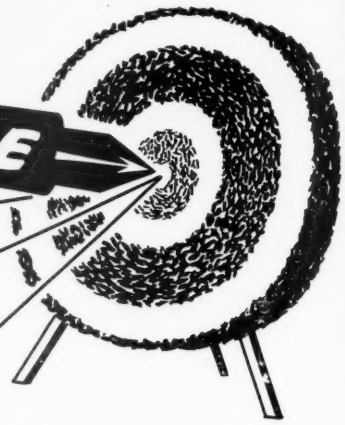
Be right in the CENTRE



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STANDARD SOLID CENTRES

Precision ground to give perfect concentricity. Tapers to standard gauges. Made in High Grade CARBON ALLOY STEEL, or HIGH SPEED STEEL BUTT WELDED.

THE ARCHER REVOLVING CENTRES

Revolve with the work and can thus stand up to the higher speeds and heavier work demanded by modern engineering practice.

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All types of centres are made from the best grade steel, and are designed to give greater efficiency, take higher speeds, and remain true under the most strenuous conditions.

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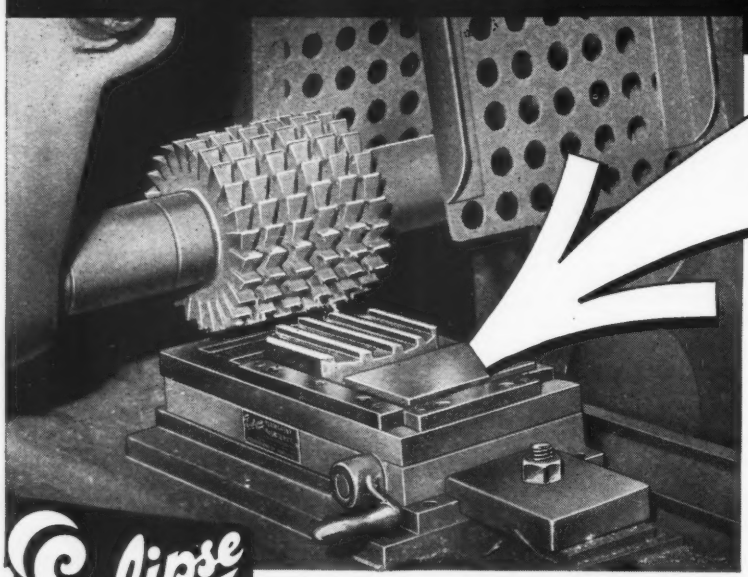
Get a good grip on gang milling



by **permagic**

Loading times are reduced, and output is increased by the use of "Eclipse" permanent magnet chucks on your milling or planing machines Efficient magnetic design ensures the greatest hold for maximum cuts and feeds.

Before you order your next milling fixture contact us — we have suggested many modifications to suit customers workpieces, resulting in a saving in initial cost.

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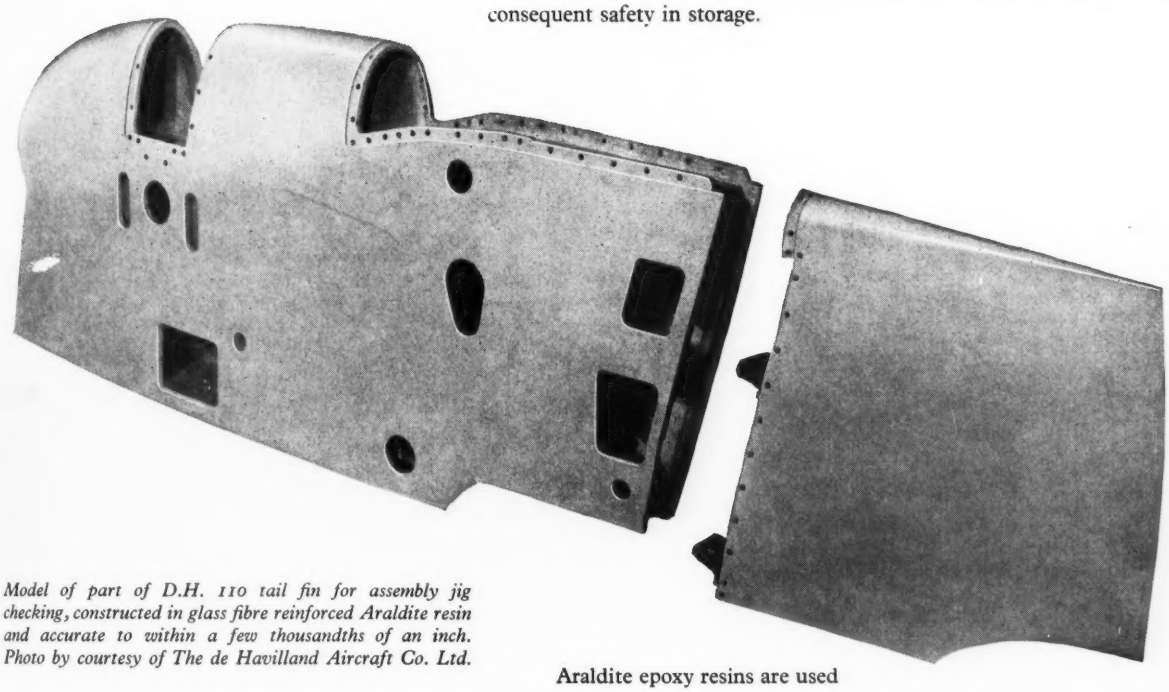
PM 127

Araldite tools shape the future

Tooling techniques with Araldite resins are being adopted more and more widely. Models, jigs, fixtures, patterns and metal-forming tools, including hammer forms, stretch blocks, rubber press tools, drop-hammer and draw dies, can all be made by simple methods with virtually no machining and a minimum of skilled manual work. Araldite tooling resins are used as gravity cast mineral-filled mixtures or with glass fibre mat or woven reinforcement, the latter providing strong, dimensionally stable, but lightweight surfaces and structures. Advantages of Araldite in tool-making include ease and speed of production, low production costs, light weight and ease of handling, negligible shinkage on curing, accuracy of reproduction, dimensional stability, durability, resistance to cutting-oils and die lubricants, resistance to moisture and chemical attack, with consequent safety in storage.



Model of part of D.H. 110 tail fin for assembly jig checking, constructed in glass fibre reinforced Araldite resin and accurate to within a few thousandths of an inch. Photo by courtesy of The de Havilland Aircraft Co. Ltd.

Araldite epoxy resins are used

- **for bonding metals, porcelain, glass, etc.**
- **for casting high grade solid electrical insulation**
- **for impregnating, potting or sealing electrical windings and components**
- **for producing glass fibre laminates**
- **for making patterns, models, jigs and tools**
- **as fillers for sheet metal work**
- **as protective coatings for metal, wood and ceramic surfaces**

The recommended techniques are simple and easily acquired. Full details and practical assistance are available upon request. May we send you a copy of our new publication on Araldite for tools, jigs and fixtures?

Araldite *epoxy resins*

Araldite is a registered trade name

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AP327

Cutting Fluids are essential to production.....

No machine shop can carry on production without cutting fluids. For that reason alone it pays to be careful on the matter of selection because the right cutting fluid effects all-round economies — in power consumption, tool life between regrinds and output in unit time. A lot also depends on correct dilution, storage and handling, matters which are adequately dealt with in the Fletcher Miller publication "Cutting Fluids" available free on request.

FLETCHER MILLER

cutting fluids

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CF 104

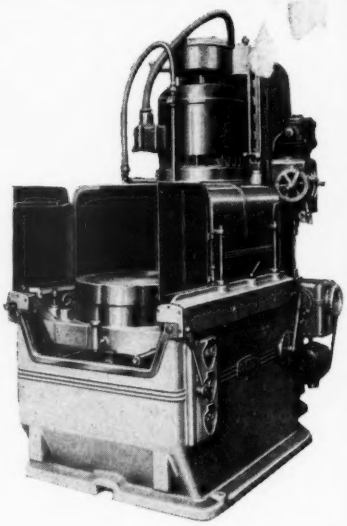
GIUSTINA HYDRAULIC PRECISION GRINDING MACHINES

MODEL RU 1000

A fully universal hydraulic grinder built for continuous production work. Rapid changeover from external to internal grinding.

Distance between centres	30", 40" or 50"
Max. work dia.	10" or 12"
Upper table swivels both ways	6°
Wheel head swivels both ways	90°
Spindle speeds	
(external grinding)	1,780-1,550 r.p.m.
(internal grinding) ...	18,000 r.p.m.

BOTH MACHINES AVAILABLE FOR IMMEDIATE DELIVERY FROM STOCK



MODEL RI 900

A vertical spindle machine with segmental wheel and rotary magnetic table. Infinitely variable table speeds. Automatic feeds.

Max. dia. of work	36"
Max. thickness of work	14"
Wheel speed	968 r.p.m.
Table speed (inf. variable) ...	6-36 r.p.m.
Auto Feed per rev. of table	.0002"-.005"

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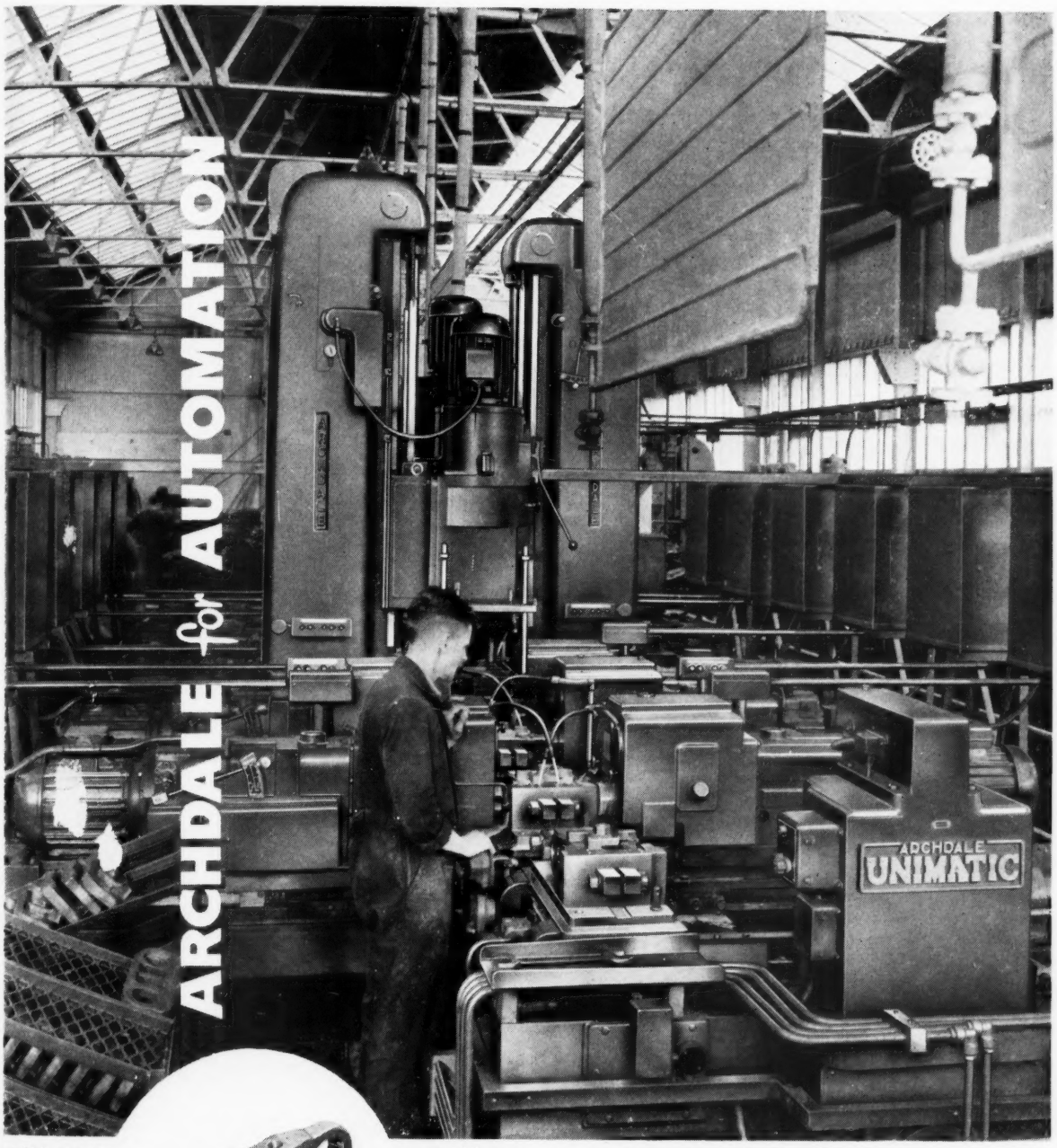

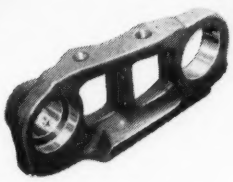

EIGHT STATION TRANSFER MACHINE

for rough and finish boring, and drilling right and left hand conveyor track links at Garringtons Ltd., Bromsgrove.

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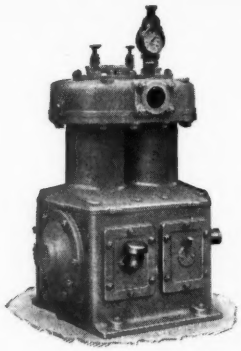

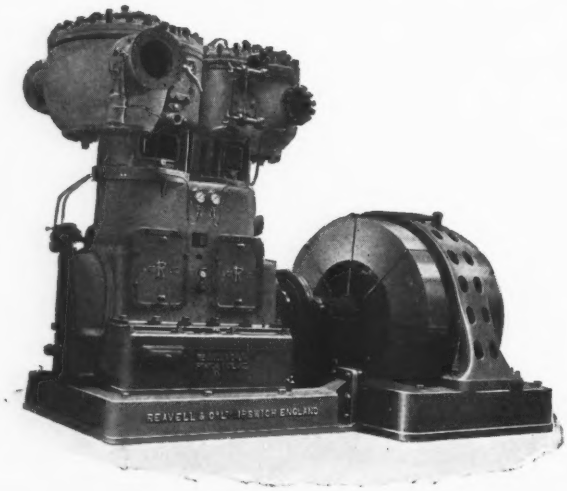

Whatever it is you need—large or small capacity—high or low pressure—we can supply the best machine for the purpose, and our fifty years of specialised experience are at your service.

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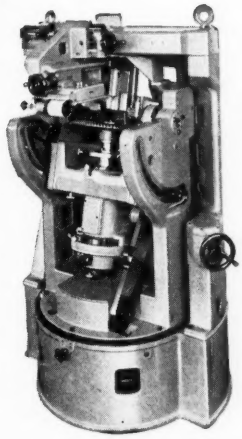
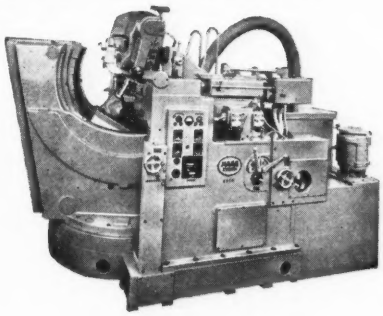
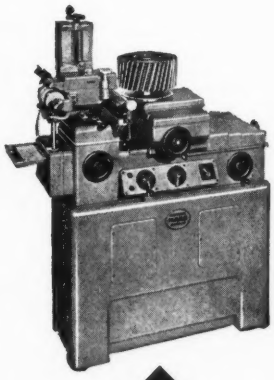
Equipment of the finest standards —designed to ensure economical high-rate production to the extremes of accuracy.

The MAAG range is most complete. These machines are representative only, but we shall be pleased to submit detailed proposals based on your production requirements.



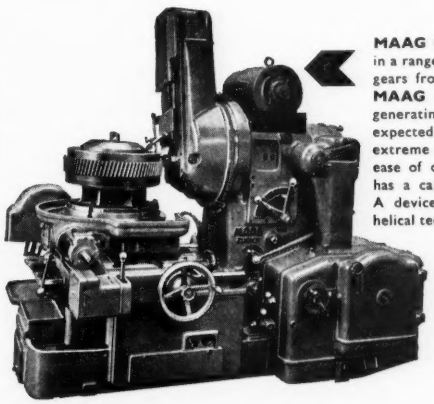




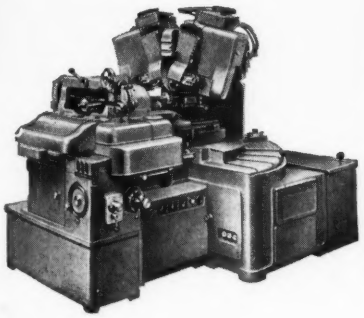
MAAG Bevel Gear Testing Machine, KP-42, is a companion to the Type KS-42 Bevel Gear Grinding Machine, right. This machine records tooth alignment, tooth thickness, tooth profile and surface finish of *bevel* gears up to 16.5 in. dia. It will measure the cone angle and the generating angle as well as the lateral displacement in the case of *oblique bevel* gears. The error magnification is adjustable between 100 : 1 and 1,000 : 1.

MAAG Bevel Gear Grinding Machine, Type KS-42, is a recent addition to the **MAAG** range for precision grinding involute tooth flanks and tooth gullets of straight-toothed *bevel* gears up to 16.5 in. dia. at a ratio of 1 : 8 (smaller dias. at lower ratios). This machine operates on the generating principle and is extremely accurate. Equally economical for individual gears or large batches.

MAAG Gear Testing Machine, PH-60, inspects, measures and records tooth profile, tooth alignment, helix angle, concentricity and surface finish of tooth flanks. Capacity 23 in. dia. Can be adapted for spur and helical *internal* gears. Other **MAAG** gear testing and measuring instruments are made in various types and sizes for checking pitch, profile, centre distance and concentricity with a precision of 0.00004 in.



MAAG Gear Cutting Machines are made in a range of sizes for cutting spur and helical gears from 0.8 in. to 200 in. dia. Like all **MAAG** machines, they operate on the generating system and possess all the qualities expected of modern machines including extreme accuracy, maximum efficiency and ease of operation. Type SH-75, illustrated, has a capacity from 1.2 in. to 29.5 in. dia. A device for cutting *internal* straight and helical teeth and racks can be supplied.



MAAG Spur and Helical Gear Grinding Machines are made in a range of sizes up to 142 in. dia. capacity. Type HSS-10 illustrated, is a high production machine for small gears up to 4.7 in. dia. This high-speed machine features infinitely variable speeds, rapid grinding times and easy change-over. Its accuracy is easily within the fine limits required for high class gears, i.e., pitch and profile errors do not exceed 0.00008 to 0.00016 in.

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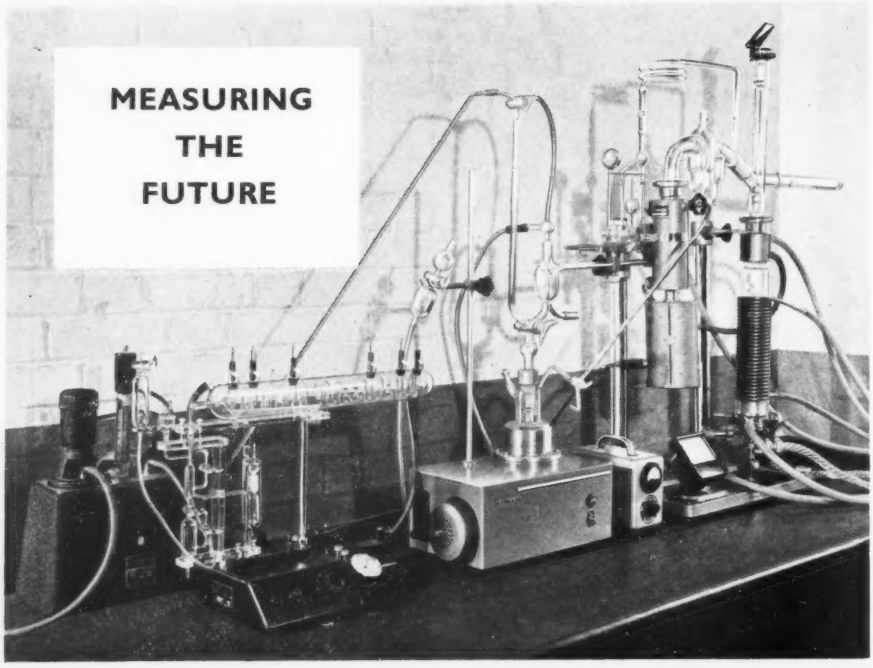

The adoption by this Company of advanced techniques for processing hard metal cutting tools in high vacuum has led to intensified research in this field. We show here a hot-extraction micro gas analyser which measures and analyses the minute amounts of gas found in cutting tool materials. The measurement and control of this factor is leading to better hard metal.

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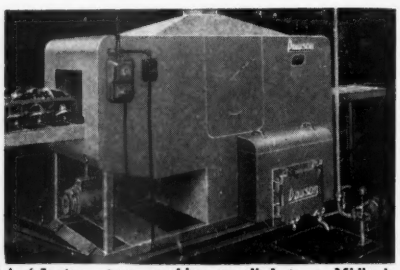
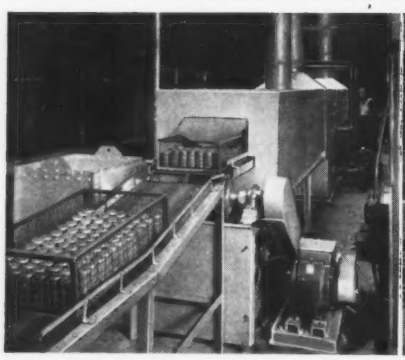
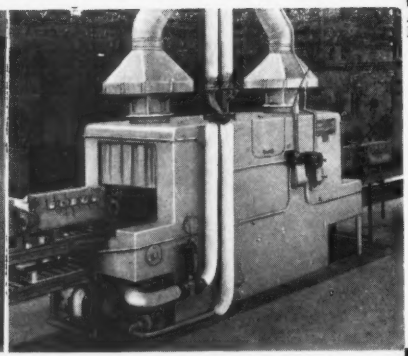


A 'Junior' type machine supplied to a Midlands Motor Car Works.



Supplied for the washing and drying of Tractor parts. Crank Shafts, Sumps, Pressings, etc.

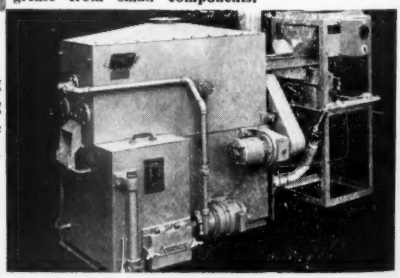


A model 'A' machine, washing parts of motor car engines prior to assembly.

Dawson

DE-GREASING AND CLEANING MACHINES

A Rotary Drum machine for removing swarf and grease from small components.



Dawson Metal Parts cleaning machines are supplied for all branches of the engineering industry. Their chief characteristics are robustness of design, small number of working parts and simplicity of operation. Space only permits the illustration of four of the many types of machines built for quick economical washing and drying of Metal Parts.

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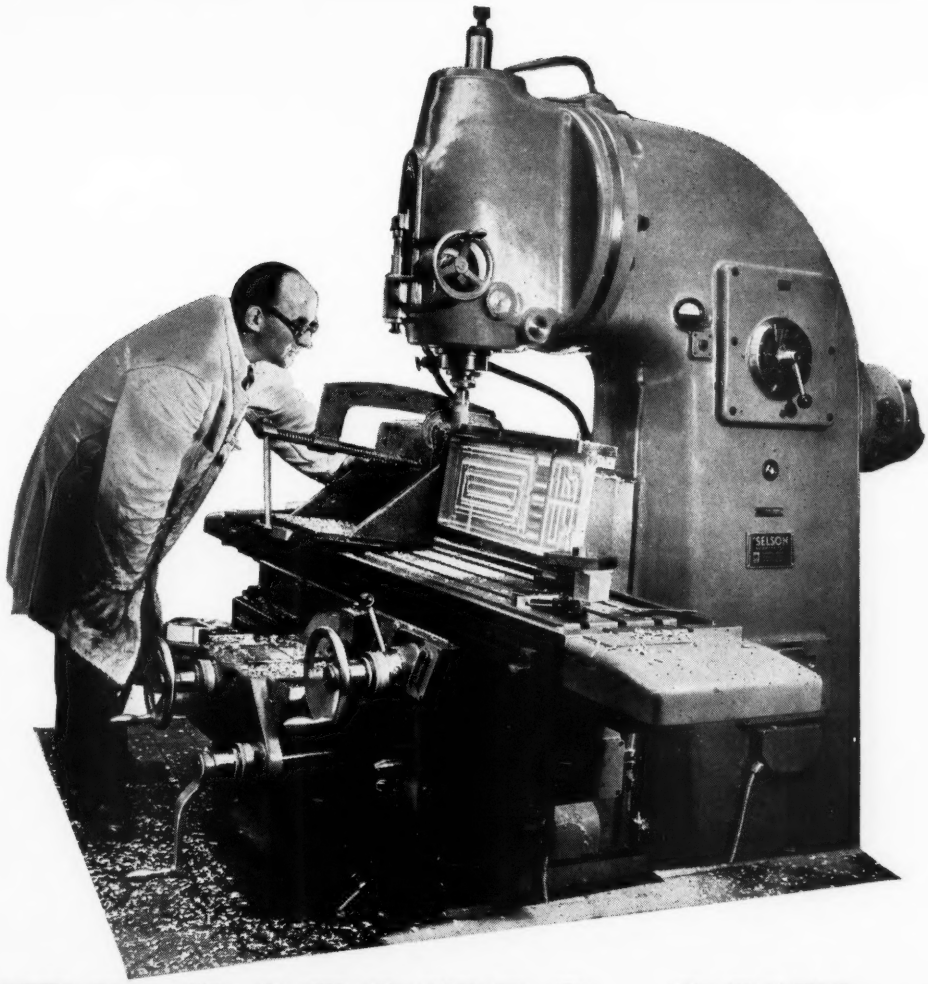

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The illustration shows a Zbrojovka Miller FA5V machining an aircraft main wing spar web from solid billet. It is installed in the Works of Messrs. C. J. C. Developments (Portsmouth) Ltd., Farlington, Portsmouth, by whose courtesy this picture is published.

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Sizes:	No. 2	No. 3	No. 4	No. 5
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Power longitudinal travel (approx.)	25″	32″	40″	50″
Power cross travel (approx.)	8″	9″	12″	16″
Spindle speeds ...	63-2800	45-2000	32-1400	18-1400

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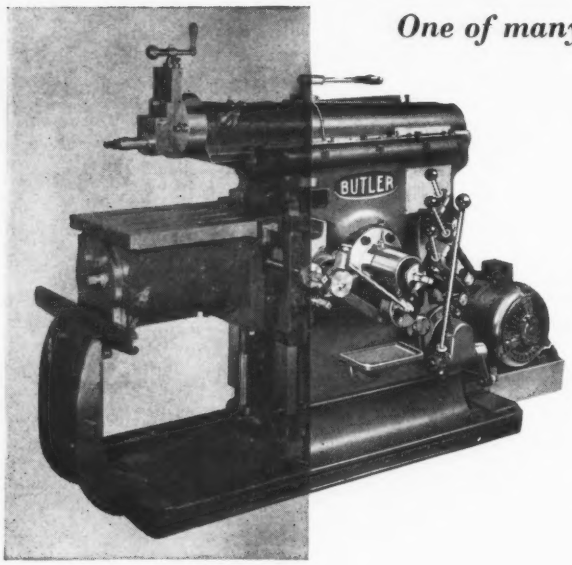

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can be designed to meet your particular cleaning problems

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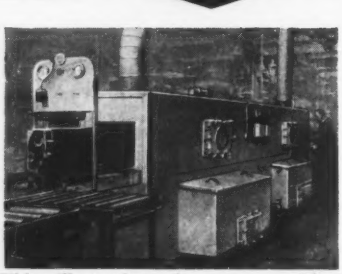
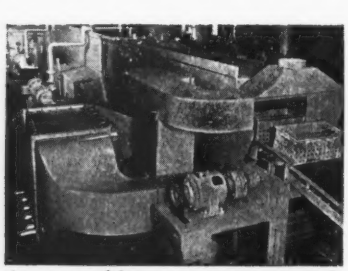
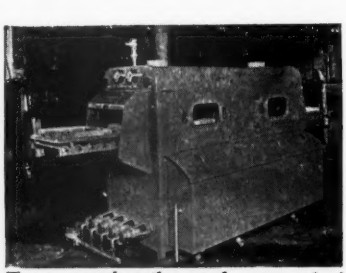


This illustration shows a machine cleaning crank cases in the production line. It is equally capable of cleaning small parts in baskets.



A power driven conveyor system is employed with this cleaning machine for ball bearings.



Trays carrying the work are pushed through on a roller conveyor by hand in this cleaning installation.

Whilst offering a very wide variety of standard cleaning equipment, it is BRATBY policy, wherever possible to design the machine to meet the particular cleaning problem. Careful study of each individual problem ensures maximum efficiency and economy of the plant in operation. The illustrations show but a few of the specific types of Cleaning Machines designed by BRATBY for individual needs.

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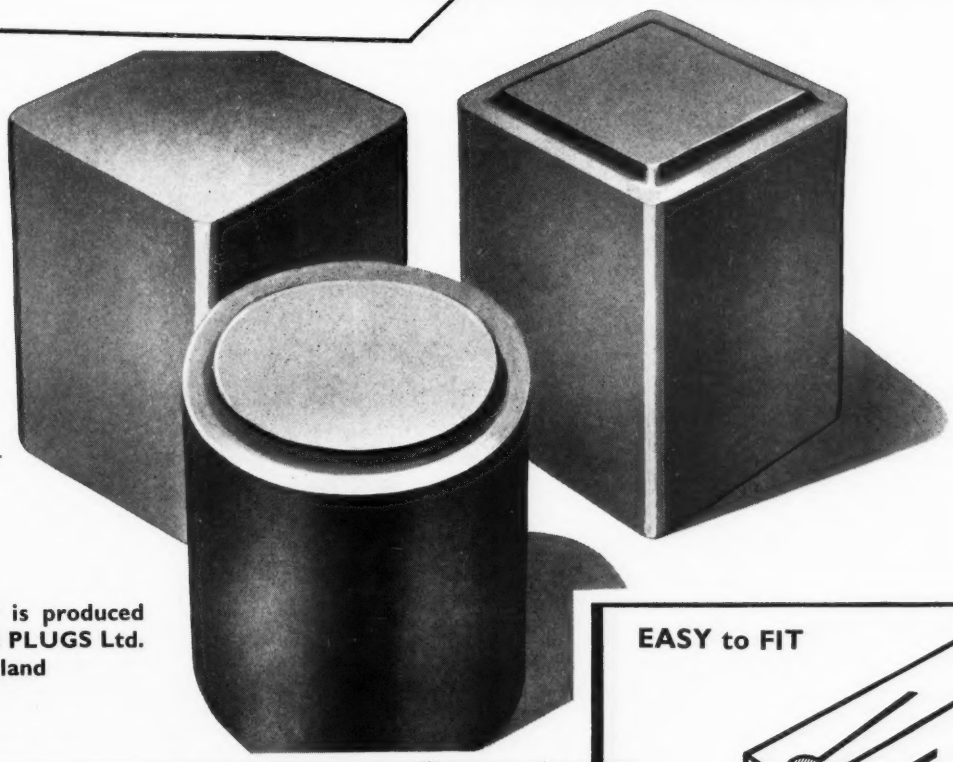

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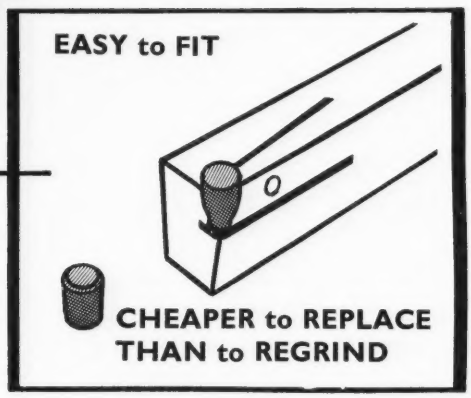

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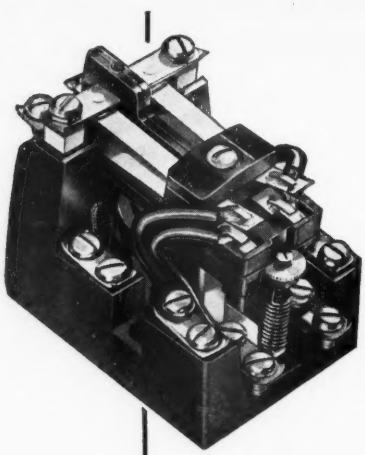

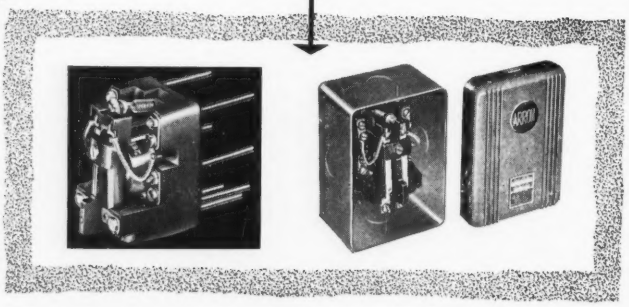

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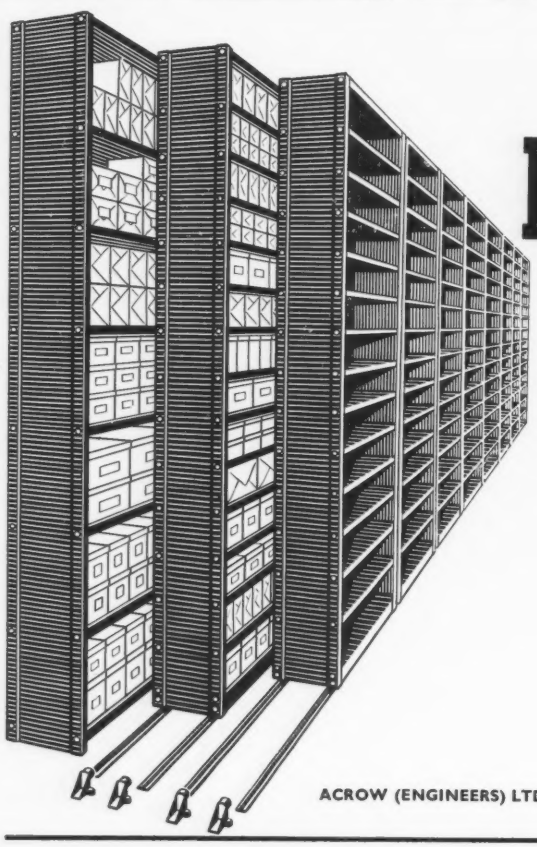

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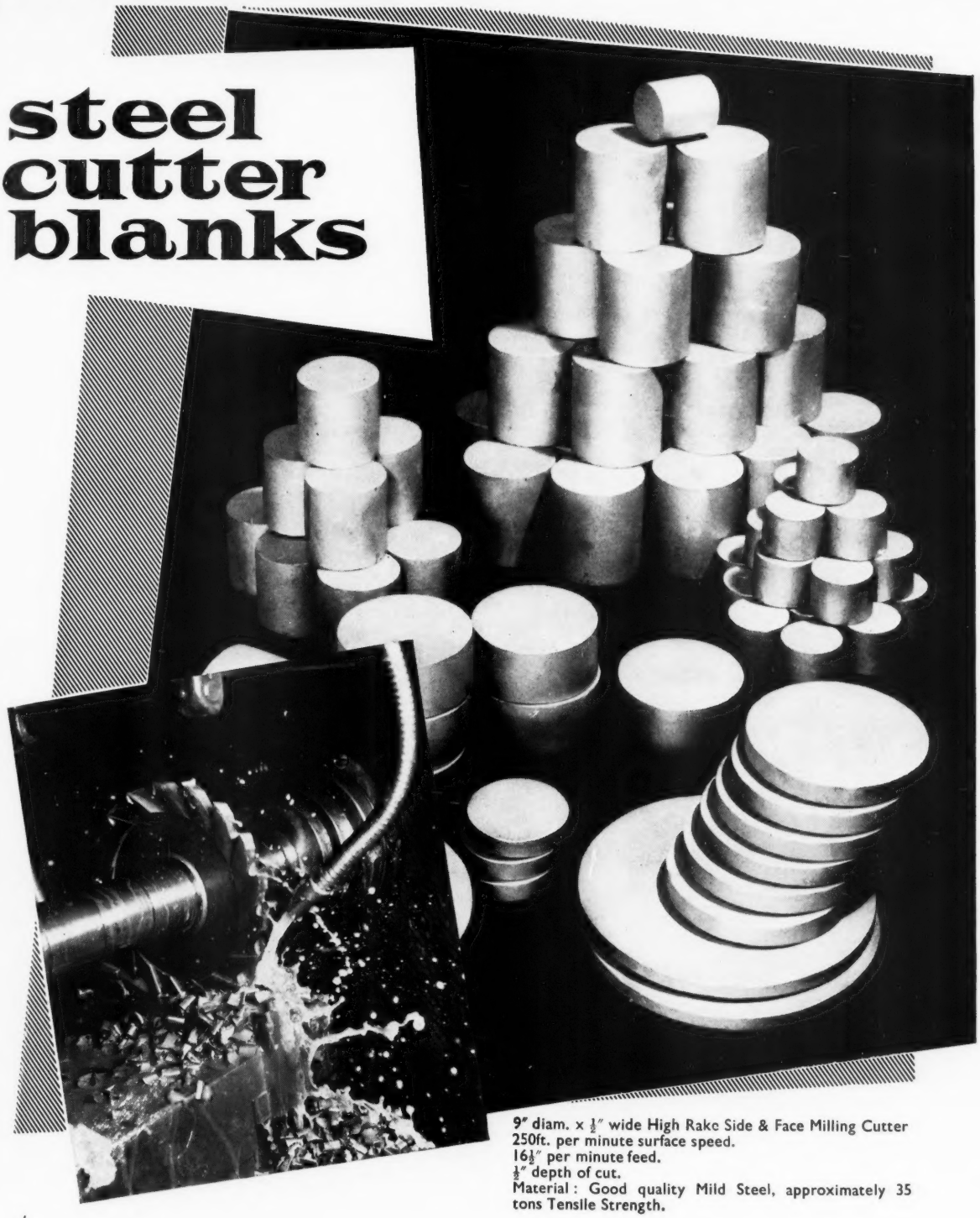

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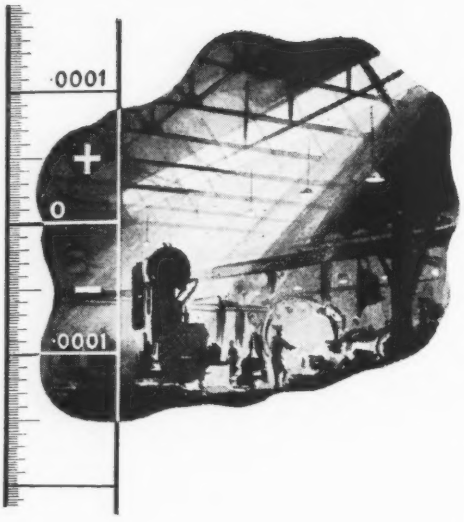

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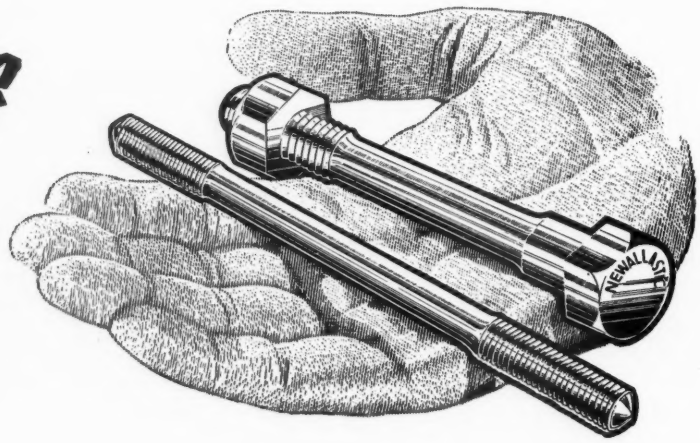

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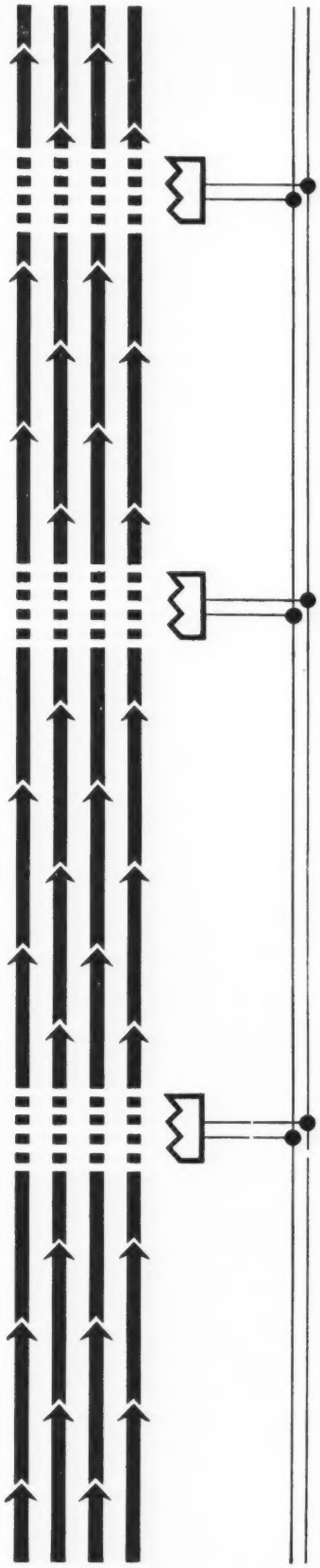

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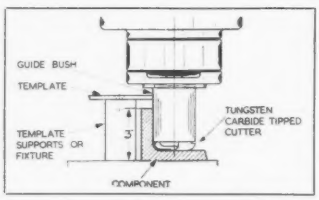

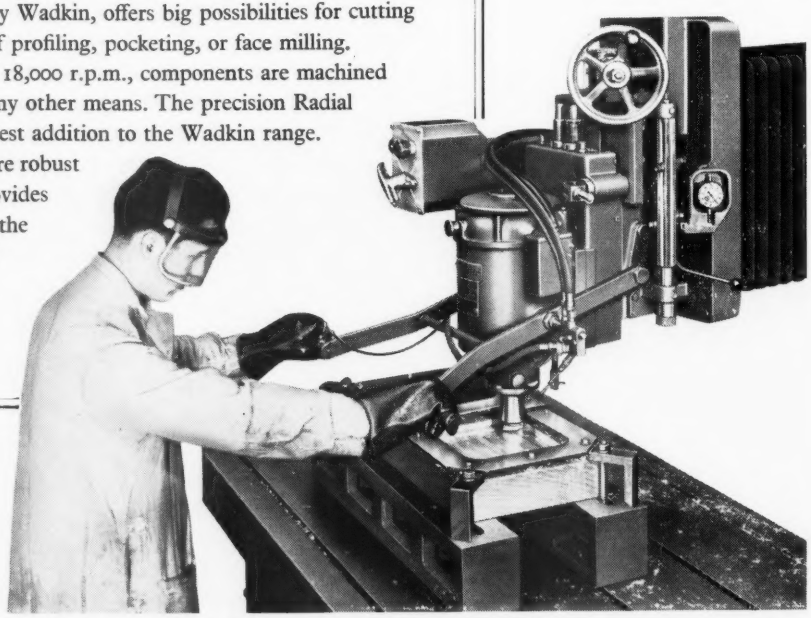

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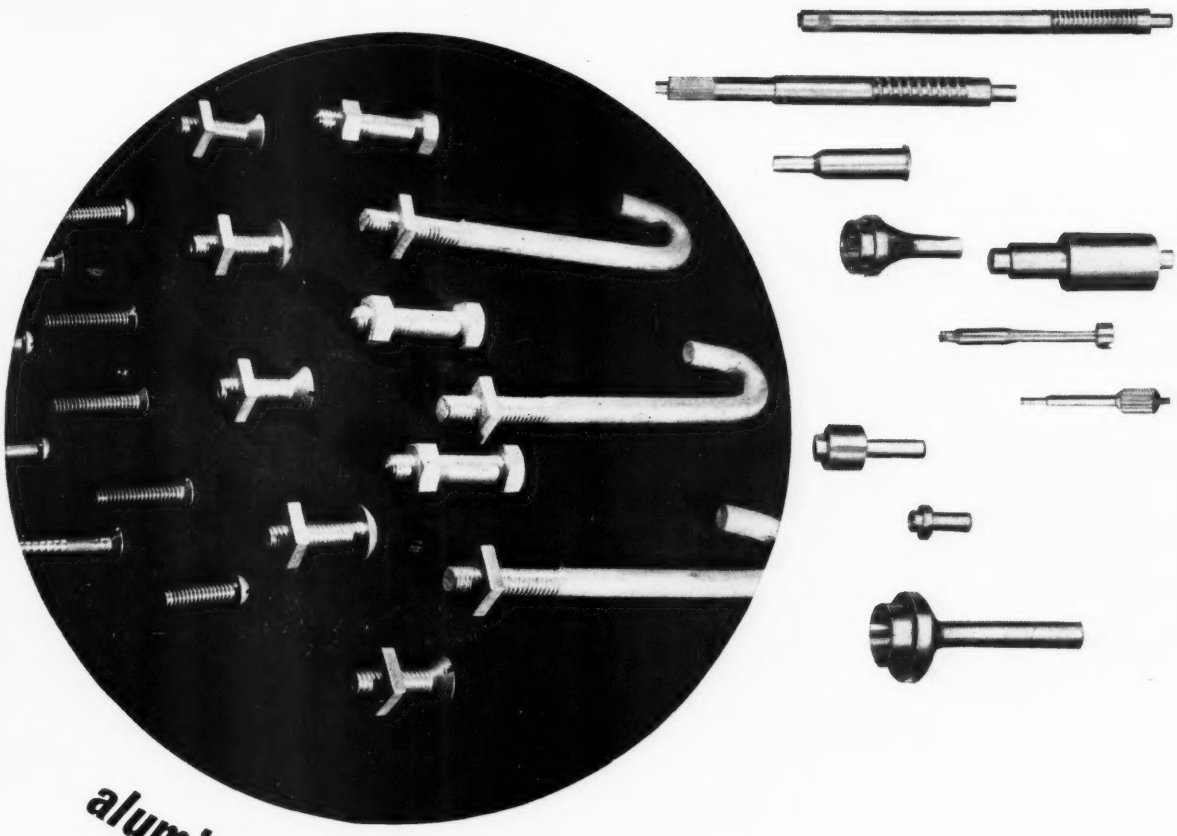
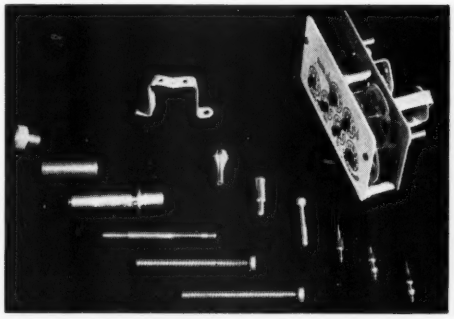


aluminium alloy rod & wire for machining



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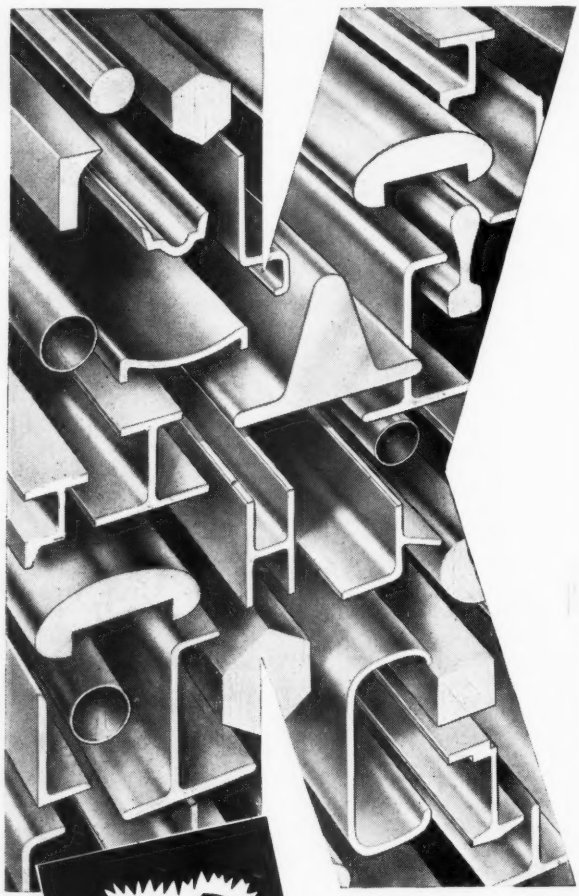

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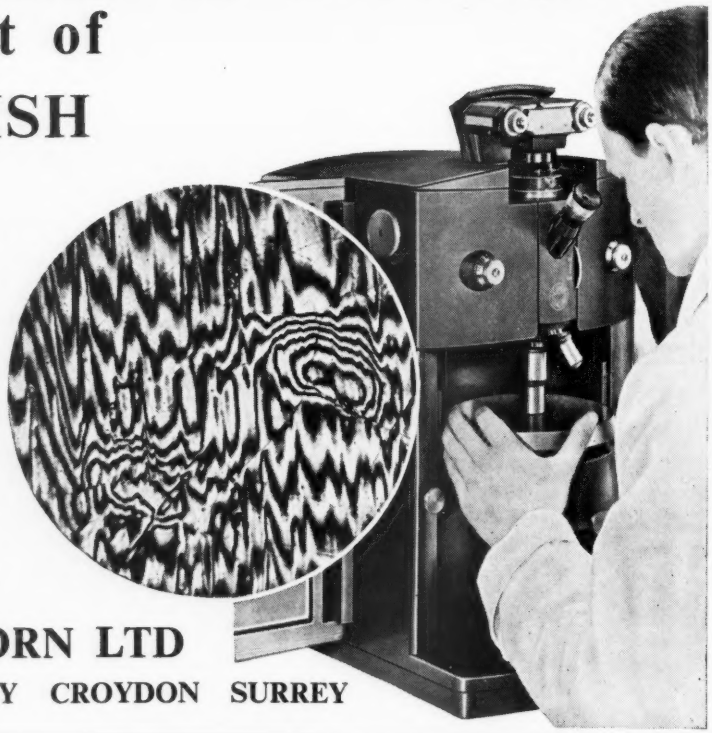

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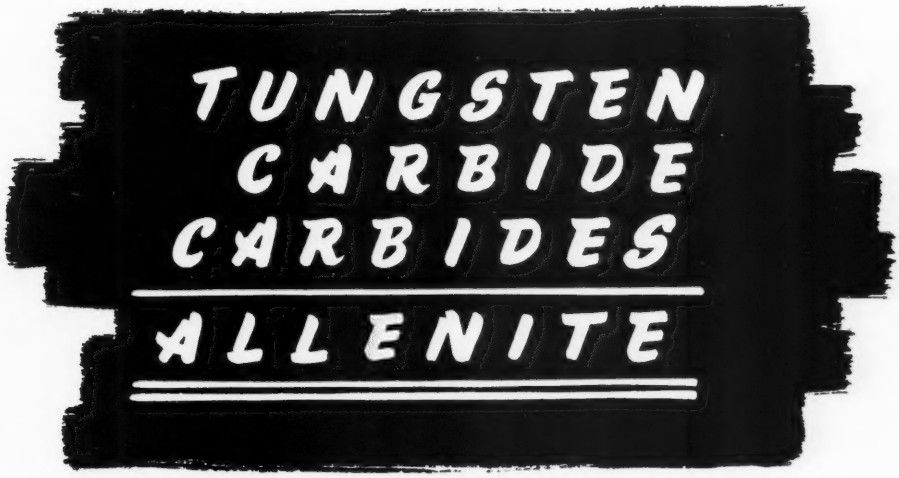

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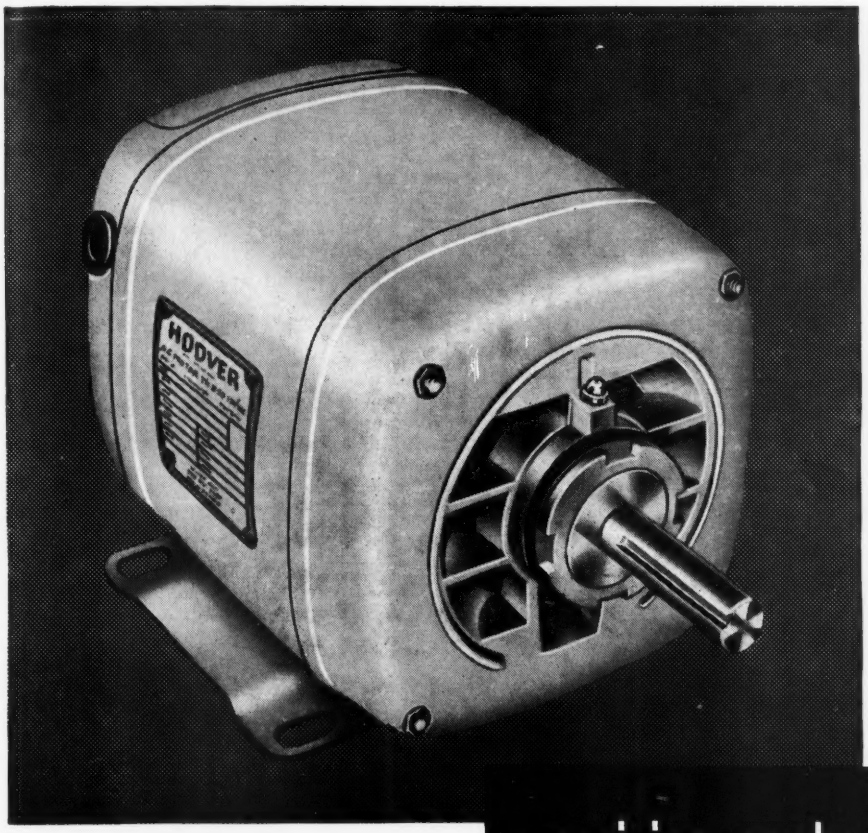

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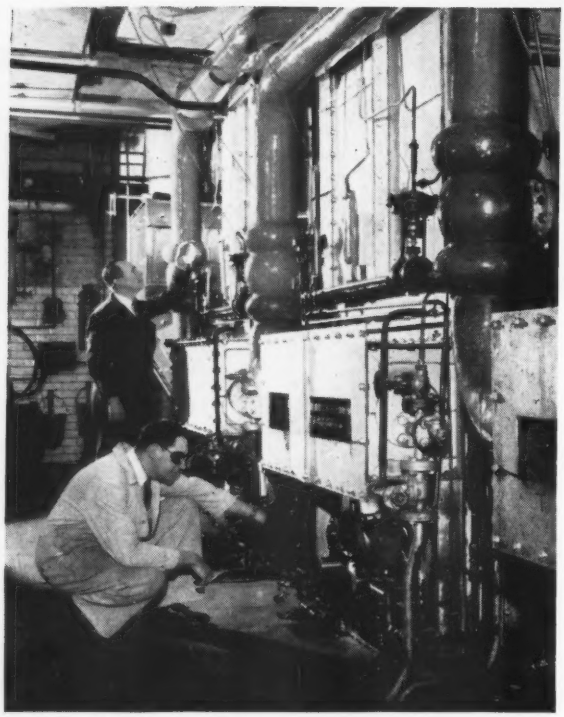

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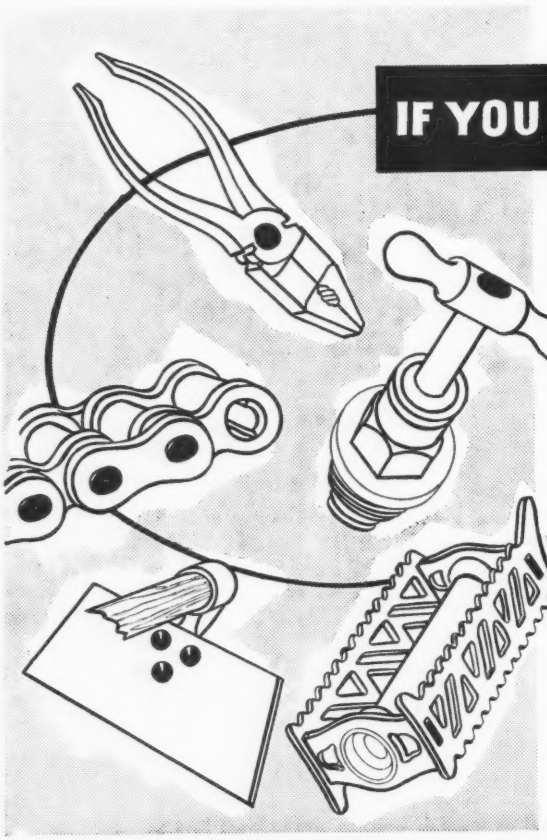

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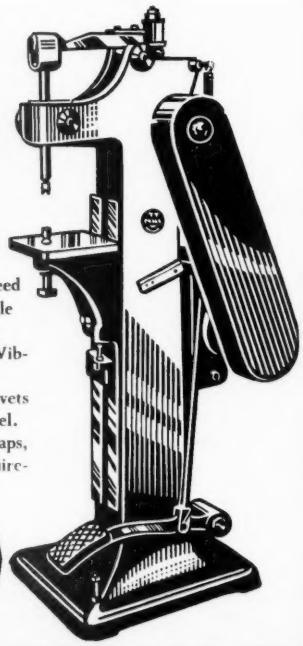

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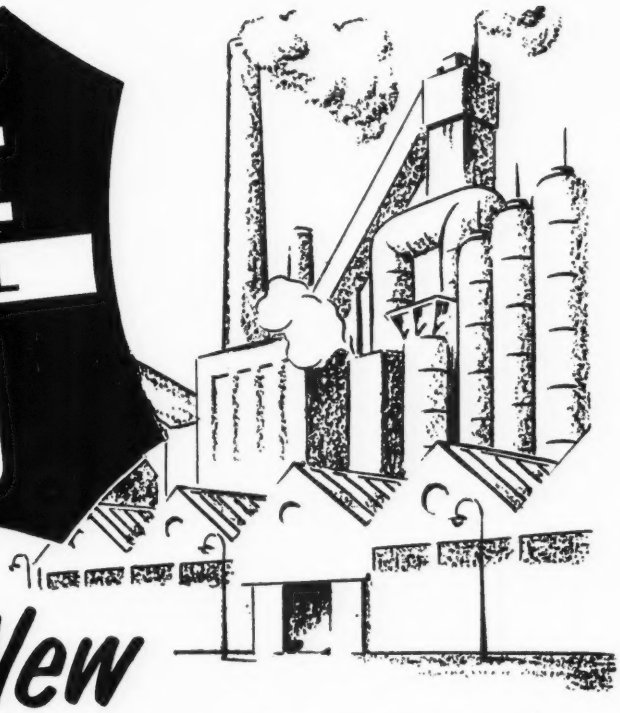

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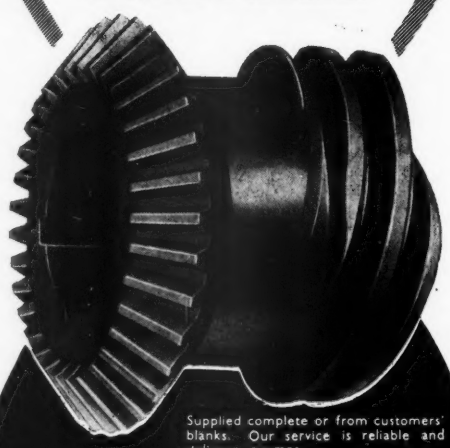

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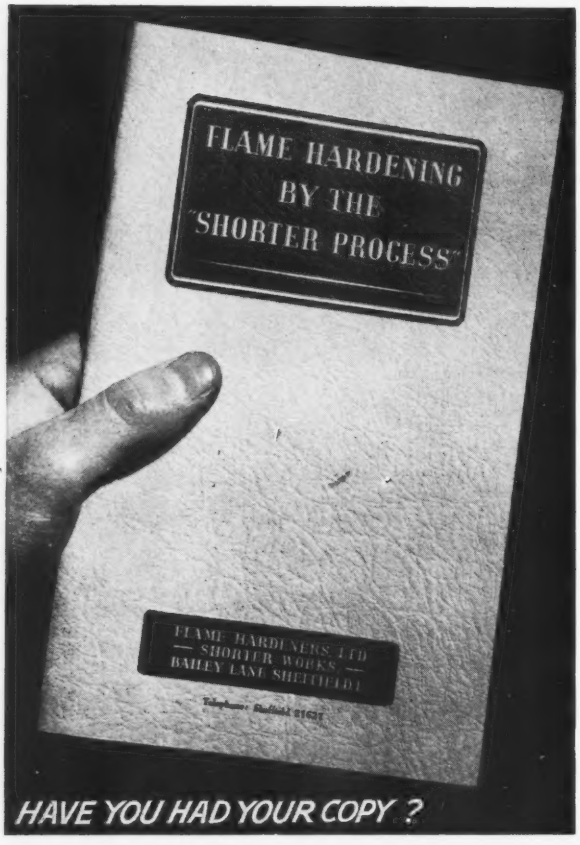

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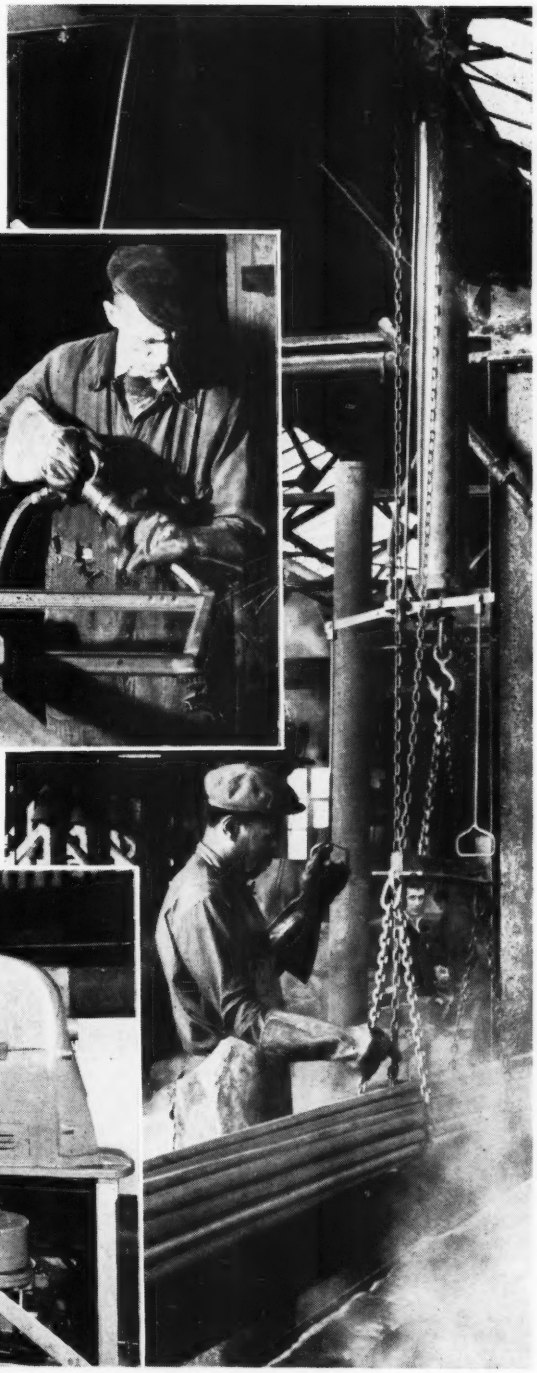

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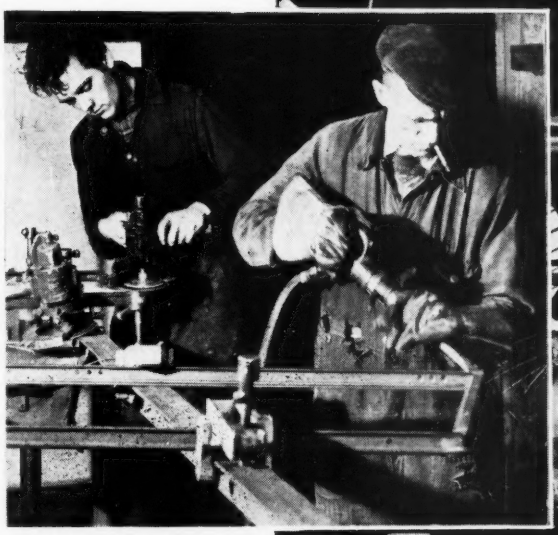
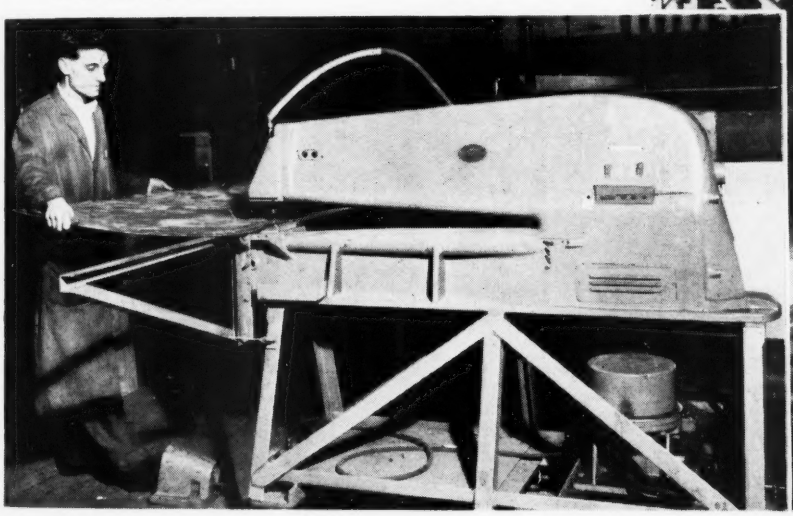


"BROOMWADE" DXIC Chipping Hammer dressing welds on window frames and "BROOMWADE" PR2 Sander fitted with unilastic wheel. Courtesy: Luxfer Ltd.



"BROOMWADE" HPS5 Squeeze Riveter counter punching a Bus side stress panel. This tool exerts a 5 ton load at the snaps. Courtesy: Park Royal Vehicles Ltd.

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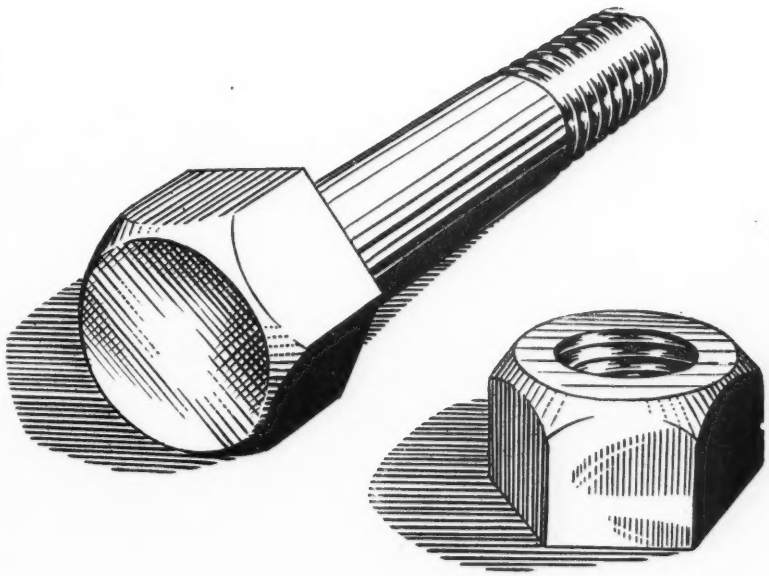

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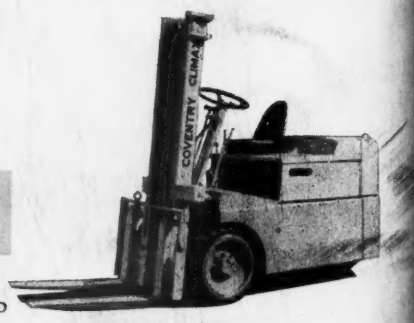

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